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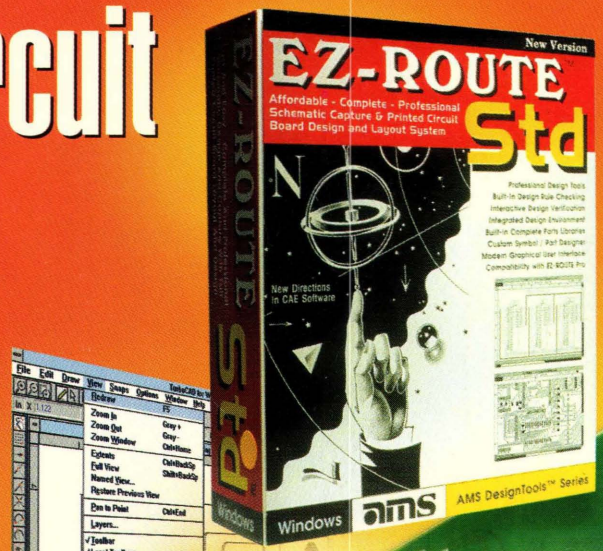

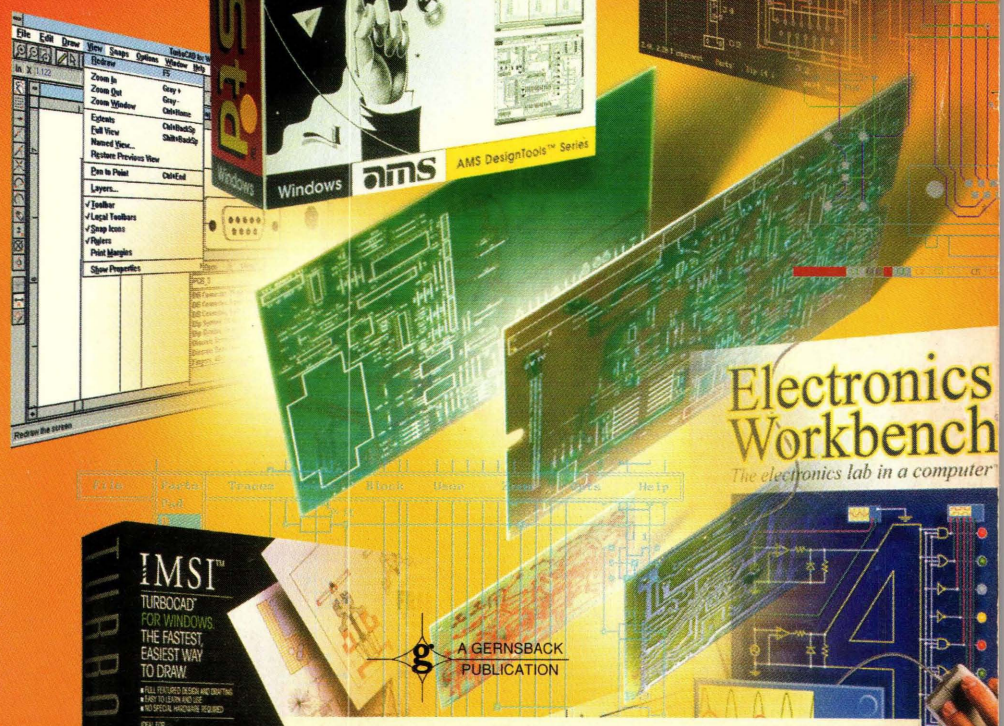

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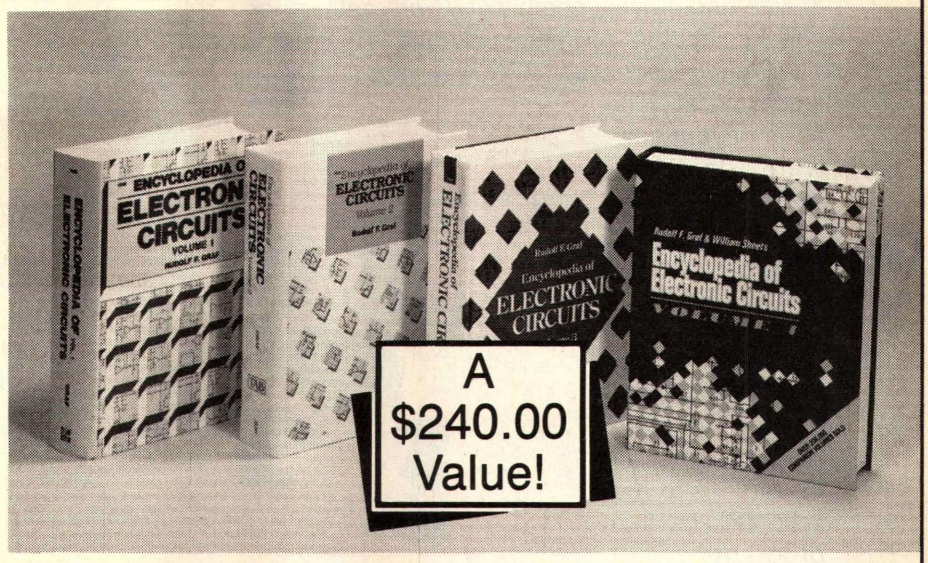

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Vol. 67 No. 1

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ON THE COVER

25 LOW-COST SOFTWARE FOR PC-BOARD DESIGN

The job of designing a printed circuit board continues to grow more demanding as components shrink in size and grow in complexity. Fortunately, personal computers can help make the job easier to bear. In this issue, we look at PC-board layout software packages that are designed to run on your desktop IBM-compatible personal computer. Each package costs less than $350. Most of the programs are linked in one way or another to the schematic-capture programs that were reviewed in the September and October 1995 issues of *Electronics Now*. A couple are stand-alone PC-board layout programs, and one, TurboCAD, is a general-purpose CAD program running with a PC-board component library. All of the packages were tested to see how they compare in price, ease of use, and features. — *TJ Byers*

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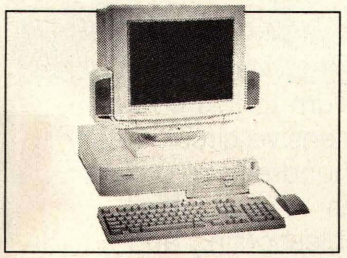

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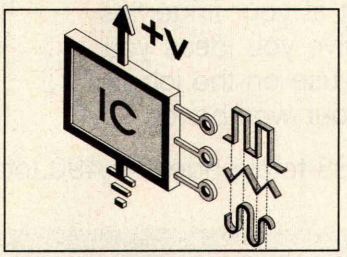

Synthesizers, IC function-generators, and LC-oscillator circuits for generating waveforms. — *Ray M. Marston*

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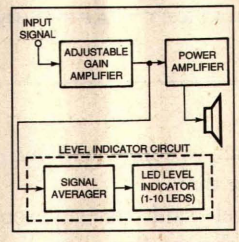

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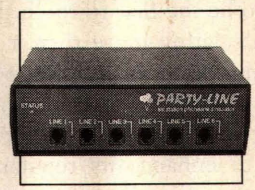

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WHAT'S NEWS

A REVIEW OF THE LATEST HAPPENINGS IN ELECTRONICS

Pentiums for supercomputers

The Intel Corporation's Beaverton, Ore. operation recently won a contract from the Department of Energy (DOE) to develop what it calls the world's fastest supercomputer. It will include 9000 of Intel's P6 microprocessors, advanced versions of its Pentium processors, yet to be introduced. The processors will be linked in a massively parallel configuration. The cost for the supercomputer has been estimated at $45 million.

The machine, when built, will be located at Sandia National Laboratories in Albuquerque, N.M. It will be used by DOE scientists to study challenging, data-intensive problems. Included among them will be simulations, the principal means for ensuring the safety, reliability, and effectiveness of U.S. nuclear weapons without actually testing them.

Intel said its supercomputer would be the first to reach the goal of calculating more than a trillion floating-point operations per second, known as a teraflop. The company sees the supercomputer as a way to enhance its reputation by demonstrating that its production microprocessors can compute in all kinds of machines from laptops to supercomputers. The Beaverton operation used custom-made microprocessors in its previous supercomputers.

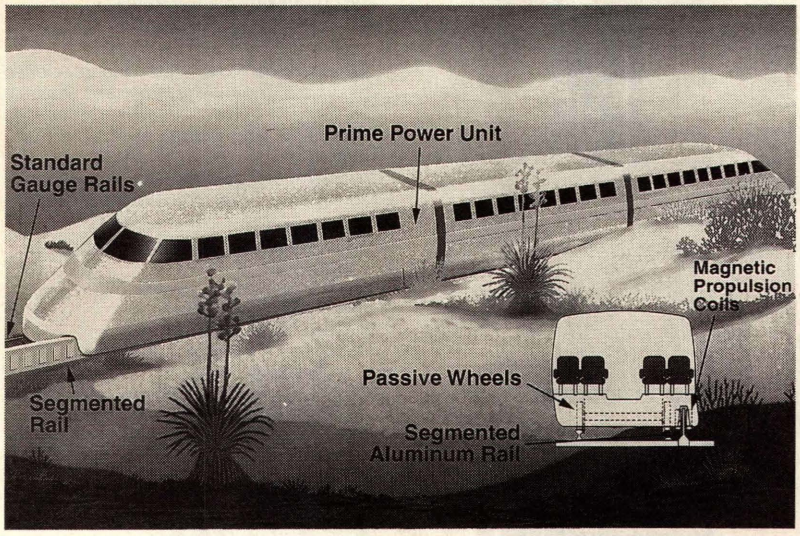
Non-levitating magnetic trains

The introduction of high-speed magnetically-levitated trains (called mag-lev) has been delayed by two major stumbling blocks: the high cost of laying suitable tracks and difficulties in obtaining the rights of way for those tracks. A new concept developed at Sandia National Laboratories, Albuquerque, N. M., has been advanced to get around those problems—a magnetically powered, high-speed train that does not levitate.

The train is called "Seraphim" (for SEgmented RAil PHased Induction Motor). Unlike mag-lev trains, which run with no engine aboard, the Seraphim would carry its own drive mechanism—a gas turbine that powers on-board electromagnets. The pulsed magnets will induce reversed electric currents in a series of aluminum plates bolted to or near the track. The induced currents will create their own magnetic fields, which oppose those of the train. By contrast, mag-lev trains are propelled by magnetic attraction from a series of stationary electromagnetic coils that must be powered along the length of the track

According to the Sandia scientists, the train would be relatively inexpensive to build, and it could run on existing track at speeds of up to 200 miles per hour. Right now, the maximum speed for passenger trains traveling between Boston, New York, and Washington, D.C. is limited to 100 miles per hour, largely by the condition of the tracks. By contrast, demonstration mag-lev trains in Germany and Japan are expected to reach speeds of 300 mph, but they require specially-designed and built track.

Nevertheless, the Sandia scientists say that Seraphim will also be able to go 300 mph on specially laid tracks. A working model, powered by magnetic coils, has reached a speed of 34 miles per hour in a dis-



ARTIST'S CONCEPT OF THE SERAPHIM HIGH-SPEED, MAGNETICALLY POWERED TRAIN shows the ladder-like reaction plates mounted vertically at the sides of the existing railroad track. The inset shows a cross section of one possible train configuration.

tance 12 feet from a standing start. This, they say has demonstrated the validity of the concept.

To facilitate its timely introduction, the Sandia-designed train would travel at speeds limited by the imperfections in existing track. "This is an incremental approach to entry into the world of high-speed, magnetically powered trains," said Robert Turman, manager of Sandia's Magnetic Propulsion Department. "We can speed up the train if the public wants it, at a later time, but more work might be required. "He explained that the curves of some sections of existing track are too sharp for high-speed trains. "At that later time, in those locations, we'd either buy new rights-of-way or elevate the track, he added.

In the Seraphim train, the fields pulse on just as the magnets pass the midpoint of the aluminum plates , triggered by optical sensors, to propel the train forward by repulsion. The aluminum plates would be pre-assembled in ladder-like sections (the plates serving as rungs) so that they could be bolted to the track rapidly and inexpensively.

The train would ride on unpowered wheels made of steel or composite materials instead of being levitated by magnetic fields. In this way, the cost and complexity of the system could be further reduced. With this approach, both conventional diesel or electric powered trains could travel on the same track as the new trains. According to Sandia laboratory estimates, the construction costs of their system would be about one-quarter of those for a mag-lev system.

Fuel cells for cars

The fuel cell has long been considered as an alternative power source for private automobiles, but many problems have kept them at arm's length. They include the handling of hydrogen required for their operation and the availability of a suitable low-emission hydrocarbon fuel. Fuel cells have been aboard space shuttles and other spacecraft, but they are costly and are designed to be self sustaining.

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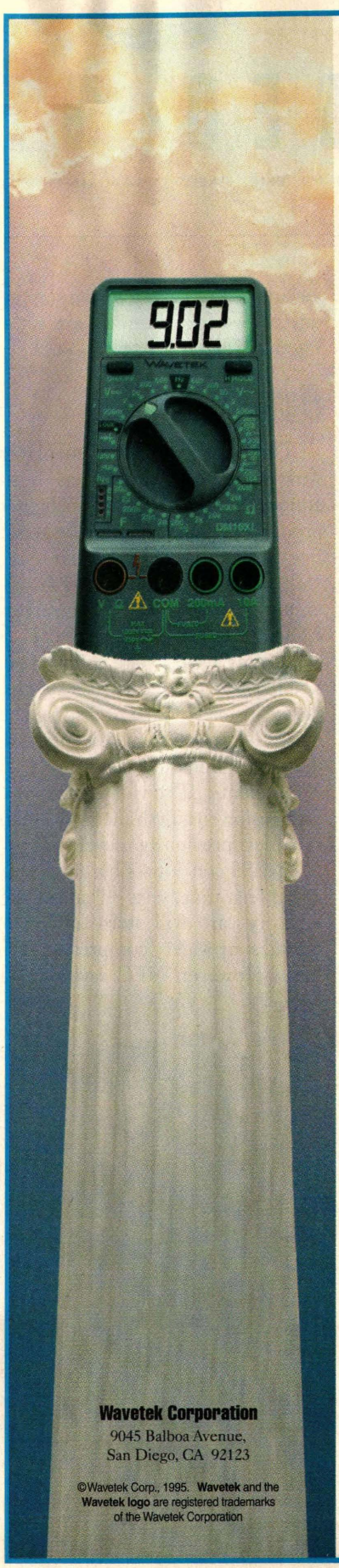

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VIDEO NEWS

WHATS NEW IN THE FAST-CHANGING VIDEO INDUSTRY

BY DAVID LACHENBRUCH

Camcorder standardization

A standard for measuring the light sensitivity of camcorders has been developed by an Electronic Industries Association (EIA) engineering committee and submitted to the American National Standards Institute (ANSI). The new standard will give meaning to low-light claims and make it possible for shoppers to make direct comparisons from make to make and model to model. Until now, there has been no standard and the same camcorder advertised as having sensitivity of one lux in the U.S. may have been rated 8 lux Japan.

The new standard recognizes that low-light sensitivity represents more than luminance alone—that the recorded picture must be viewable. Therefore, five different parameters are involved, with minimum standards established for each: luminance level, black level, luminance signal-to-noise ratio, chroma level, and resolution. Measurements can be made using standard test equipment and four easily available charts: standard gray scale chart, 18% gray card, resolution chart, and color chart. Therefore, any well-equipped service shop can check manufacturers' claims.

The standard is entirely voluntary, but it is already being adopted by manufacturers for products to be released this year in the United States. All camcorders and video cameras using the new standard will be identified in ads and instruction manuals as in terms of brightness in lux "measured by the EIA method." It's expected that many camcorders which previously would have been advertised as having sensitivity of one or two lux will now have to be rated at five, six, or seven lux.

Flash video player

The first practical video player with no moving parts has been announced by NEC in Japan, but production still appears to be about five years in the future. The tiny "Silicon View" player is self-contained with its own 2.5-inch color LCD and battery and fits in a pocket. It uses a solid-state credit-card-size flash-memory card as a storage device instead of tape or disc for the MPEG-1 quality video picture, thereby eliminating all mechanical components. The video player is a companion to a flash memory audio recorder previously developed by NEC. Silicon View's big drawback is playing time. Its 40-megabyte memory card will store only four minutes of video compressed 23-fold. However, NEC says that in five years it expects 1-gigabit DRAMs to be available in quantities. Using four of these would provide one hour of planning time.

Flash memories, meanwhile, are being developed for a variety of purposes, and the first practical use is expected to be as electronic "film" for consumer-priced digital still cameras. Twelve companies have formed the Compact Flash Association to promote wider use of flash memories and to standardize their use and parameters. Flash cards can hold millions of characters of information and plug into a wide variety of devices, retaining the information when power is turned off or they are removed from a device. They're expected to be used wherever large memory is required in small size.

Flash cartridges are about the size of a pocket matchbox measuring 1.4 by 1.7 inches and 0. 13 -inch thick. They are currently available

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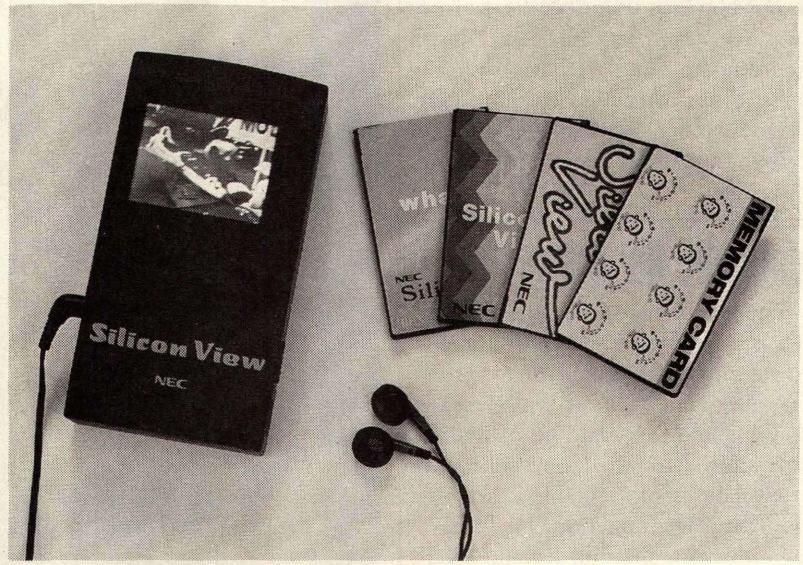

NEC'S SILICON VIEW player has a 2.5-inch color LCD screen. A solid-state flash-memory card, shown to the right, contains the digitally compressed video information.

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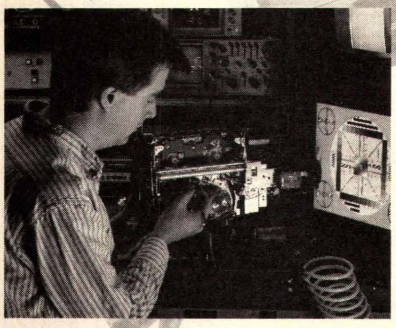

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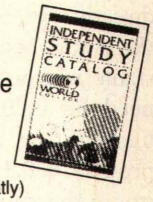

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Q & A

READERS QUESTIONS, EDITORS ANSWERS

12-Volt Blinker

Q *I would like to connect a 7805 voltage regulator that is fed from a 12-volt battery to a blinking red LED. Do I need capacitors on the regulator and a limiting resistor on the output side to the blinking red LED? I prefer not to use the LM3909 for lack of space.—G. Ross, Vancouver, B.C., Canada*

A A blinking red LED, such as Radio Shack's 276-036, contains its own current limiter along with the blinking circuit; you can connect it to the output of a 7805 directly. No capacitor is needed at the output because the 7805 is quite stable without one, and you don't need the slight improvement in regulation that the capacitor would provide. A 0.33-µF or larger capacitor at the input is recommended to ensure stability, but it might not be necessary (see Fig. 3). To save even more space, you could use a 78L05, which is the low-power version of the 7805, but with a 100 milliampere maximum output current. Refer back to Fig. 2 for the pinouts.

You're quite right not to use the LM3909 in this application—it would require a rather bulky capacitor (about 300 µF). The main purpose of the LM3909 is to flash an LED from a 1.5-volt battery, even though the LED requires 1.8 volts or more. It does this trick by charging the capacitor and then momentarily putting it in series with the battery so that the voltages add.

Power Supply Problems

Q *I am having problems with a positive/negative 12 volt regulated power supply (see Fig. 1). Whenever power is applied to the circuit, the 7812 regulator overheats and the 7912 provides a voltage that is less than –12 volts. Can you tell me what's wrong?—M. Schoppert, Orlando, FL*

A Taking your first question first, one "gotcha" of negative power supply design is that the pinout of a 7912 isn't the same as a 7812 (see Fig. 2). (Due to a drafting error, some of the pin numbers in our April column were incorrect.)

If mixed-up pins aren't the problem, try removing both of the voltage regulators and see what happens. If the voltages are normal (about 15 to 20 volts, unregulated, on each side), reinstall the regulators one at a time to identify the defective one. If you don't get normal voltages even with the voltage regulators removed, check the capacitors, diodes, and transformer.

The 0.1µF capacitors at the outputs improve the regulation and help to ensure stability; the capacitor is optional with the 7812 but required with the 7912.

Cable Shielding

Q *I've made a power supply for an audio amplifier. The amplifier has a humming noise when it's run on AC but is fine when run on DC. Does the transformer need more shielding?—M. Schoppert, Orlando, FL*

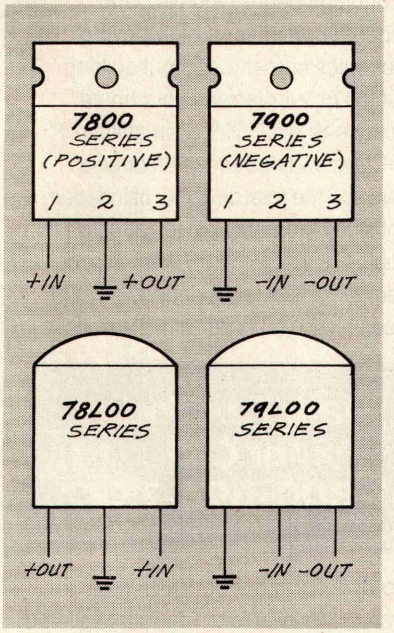

FIG. 2—VOLTAGE REGULATOR PINOUTS aren't all the same. Note differences between positive and negative, and between full-size and low-power versions.

Q *I attempted to hook the stereo output of my VCR to the high-level input on my stereo through an audio switch box. I used regular unshielded audio cable and the length was about 50 feet. There was an enormous amount of hum. The layout of the room is such*

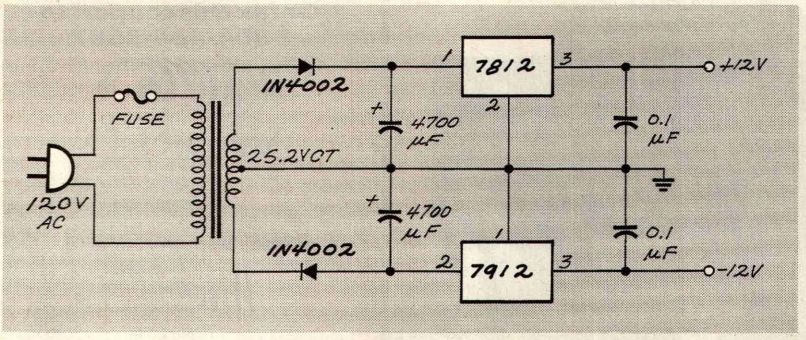

FIG. 1—SPLIT POWER SUPPLY DESIGN.

that it is impractical to move the stereo and VCR closer to each other. I would appreciate any help offered.—C. Pritchard, Brownsburg, IN

A Now both of you know why they make shielded cable. We live in a sea of 60-Hz electromagnetic fields which come from house wiring and are easily picked up by sensitive audio amplifiers, resulting in hum. Near a TV set, there are also strong 60-Hz and 16-kHz fields from the deflection yoke. Shielded cables keep this hum out of the audio. They also keep the amplifier from picking up its own output, which would cause oscillation.

For long cable runs, you might want to use microphone cable or RF cable (RG-8, RG-58, or the like), which has better shielding than ordinary audio patch cords. Make sure that all of the equipment is grounded as specified in its instructions. If any of the items has an unpolarized AC power line plug, try reversing the plug to see if the hum decreases.

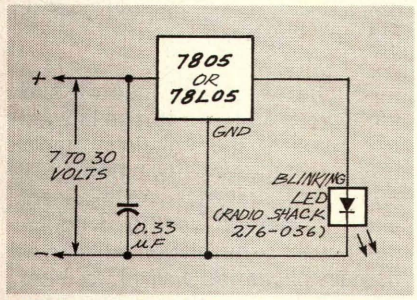

FIG. 3—12-VOLT LED FLASHER CONFIGURATION.

In homebuilt equipment, it's important to build sensitive amplifiers compactly, keeping inputs away from wires that carry AC power. Metal enclosures improve shielding. Two other sources of hum are power supply ripple (unlikely if you're using a regulator IC) and coupling from the transformer. Ripple will diminish if you use a larger filter capacitor; transformer coupling will diminish if you put the transformer just a few inches farther from the circuit.

Speaker cables don't have to be shielded because the speaker impedance is so low (8 ohms) that it would take a gigantic amount of 60-Hz energy to have any audible effect. Telephone wires are unshielded because telephones don't pick up sig-

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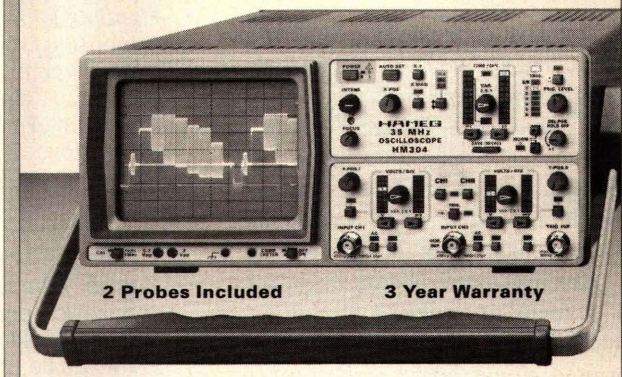

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Automotive and Kit Questions

Q *Do you have plans on how to convert my 40-amp alternator into a high-amp alternator? Also, are there any kit companies left anywhere? I am interested in building a PC and a TV.—R. Christman, Friendship, WI*

A The alternator question is easy: just take out the old alternator and put in a higher-amperage one, together with the appropriate voltage regulator. Converting an existing alternator isn't practical because you'd have to completely rewind it with heavier wire, which wouldn't fit in the space available.

Kits disappeared because electronic equipment no longer must be wired by hand. It's cheaper to assemble a printed circuit board with automatic machinery than to pack the parts in a box and ship them to the customer for assembly. However, a color TV kit is still available: The Graymark 544 is available from Quantum Electronics, 4 Brisbane Way, Irvine, CA 92715; Tel. 800-858-WATT

For a PC, you don't really need a kit; just order a suitable case, power supply, motherboard, disk drives, and other components from whoever gives the best deal, and put them together. Every town has several people in it who make their living doing just this.

The kits that remain available are generally small items with hobbyist appeal. The biggest kit company is Ramsey Electronics, 793 Canning Parkway, Victor, NY 14564 (1-716-924-4560); they specialize in unusual radio receivers, transmitters, and test equipment.

Old Oscilloscope Manual

Q *Where can I get a manual for an Eico model 460 oscilloscope?—J. T. Haynes, Newark, NJ*

A Eico can still be reached at 363 Merrick Road, Lynbrook, NY 11563. Also try Hi Manuals, PO Box 802, Council Bluffs, IA 51502. For general information see "New Life for Old Oscilloscopes," *Electronics Now*, September 1994, pp. 57-64.

HOW TO GET INFORMATION ABOUT ELECTRONICS

Books: Several good introductory electronics books, including *Building Power Supplies,* are available at Radio Shack.

Our favorite general electronics textbook is *The Art of Electronics,* by Paul Horowitz and Winfield Hill, available from the publisher (Cambridge University Press, 1-800-872-7423) or on special order through any bookstore. Its 1125 pages are full of information on how to build working circuits, with a minimum of mathematics.

Also indispensable is *The ARRL Handbook for Radio Amateurs,* comprising 1000 pages of theory, radio circuits, and ready-to-build projects, available from the American Radio Relay League, Newington, CT 06111, and from ham radio equipment dealers.

Copies of past articles in *Electronics Now, Radio-Electronics, Popular Electronics,* and *Hands-On Electronics* are available from our Reprint Bookstore, PO Box 4099, Farmingdale, NY 11735 (516-293-3751).

Electronics Now and many other magazines are indexed in the *Readers' Guide to Periodical Literature,* available at your public library. Copies of articles in other magazines can be obtained through your public library's interlibrary loan service; expect to pay about 30 cents a page.

The full text of *Electronics Now is* available in the electronic versions of the *Readers' Guide to Periodical Literature. Electronics Now* is also abstracted and indexed in *Academic Abstracts and Magazine Article Summeries* (83 Pine Street, Peabody, MA 01960; Tel: 800-653-2726).

Service manuals for radios, TVs, VCRs, audio equipment, and some computers are available from Howard W. Sams & Co., Indianapolis, IN 46214 (1-800-428-7267). The free Sams catalog also lists addresses of manufacturers and parts dealers. Even if an item isn't listed in the catalog, Sams may have a schematic on file that can be copied for you.

Manuals for older test equipment and ham radio gear are available from Hi Manuals, PO Box 802, Council Bluffs, IA 51502.

Replacement transistors, ICs, and other semiconductors, marketed by Philips ECG, NTE, and Thomson (SK), are available through most parts dealers (including Radio Shack on special order). The ECG, NTE, and SK lines contain just a few hundred parts that substitute for many thousands of others; a directory (supplied as a large book and on diskette) tells you which one to use. NTE numbers usually match ECG; SK numbers are different.

Remember that the "2S" in a Japanese type number is usually omitted; a transistor marked D945 is actually a 2SD945.

Hamfests (swap meets) and local organizations can be located by writing to the American Radio Relay League (Newington, CT 06111). A hamfest is an excellent place to pick up used test equipment, older parts, and other items at bargain prices, as well as to meet your fellow electronics enthusiasts both amateur and professional.

Writing to Q&A: We welcome your questions. The most interesting ones are answered in print, usually within 6 to 9 months. Please be sure to include plenty of background information (we'll shorten your letter for publication). We regret that we cannot give personal replies.

Catch the Wind?

Q *I'm trying to measure and record wind speeds in isolated areas. I've looked for a portable, self-powered tachometer, but all I've found are systems that need an outside power supply.—K. W. Symons, Provo, UT*

A You might try using a small hobby-type DC motor as a generator, connected to a voltmeter (analog, not digital, in order to absorb fluctuations). The voltage should be roughly proportional to the speed of rotation, which in turn will indicate wind speed. EN

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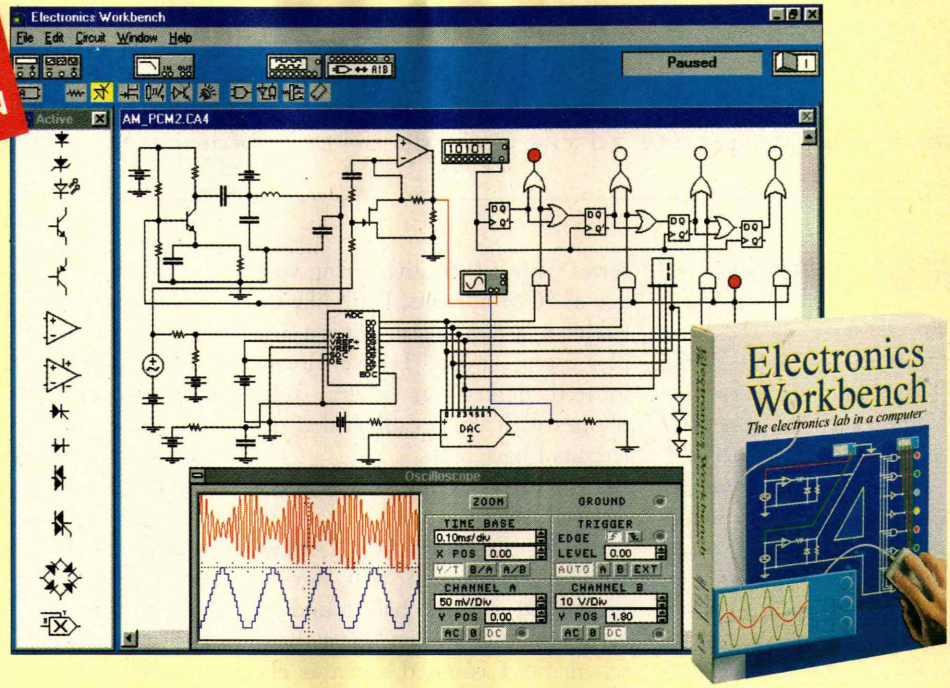

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LETTERS

SEND YOUR COMMENTS TO THE EDITORS OF ELECTRONICS NOW MAGAZINE

MUSIC VISION CORRECTIONS

*An error appeared in the parts placement diagram (Fig. 10) of the article, "Music Vision" (*Electronics Now, November 1995*). The label for resistor R59 was incorrectly placed; It appeared as an unlabeled jumper located below R60. In addition, the solder-side of the PC board was reversed in the X-ray view, Fig. 10. The corrected version is shown below.*—Editor

TELCO IN A BOX CORRECTIONS

I spotted an error in the article, "Telco in a Box" (*Electronics Now*, September 1995). and a corrected schematic was published. Since then, I have found two other errors. First, resistors R1 and R2 should be at least one-watt resistors but two watts would be better if you want to make allowance for a telephone with an internal short circuit.

Second, the author stated that the telephone company's ring signal pulses "the 50-volt DC line voltage on and off at about 20 Hz." I have found that the ring voltage is much higher than that, and available ring generators provide a much higher voltage. For example, the JEC TECH RG-1 ("Phone Line Simulator," *Electronics Now*, August 1993) has an output of about 85 volts at 20 Hz. The output of the telephone ringing generator module, No. 56-374, from Hosfelt Electronics is 180 volts peak-to-peak at 20 Hz.

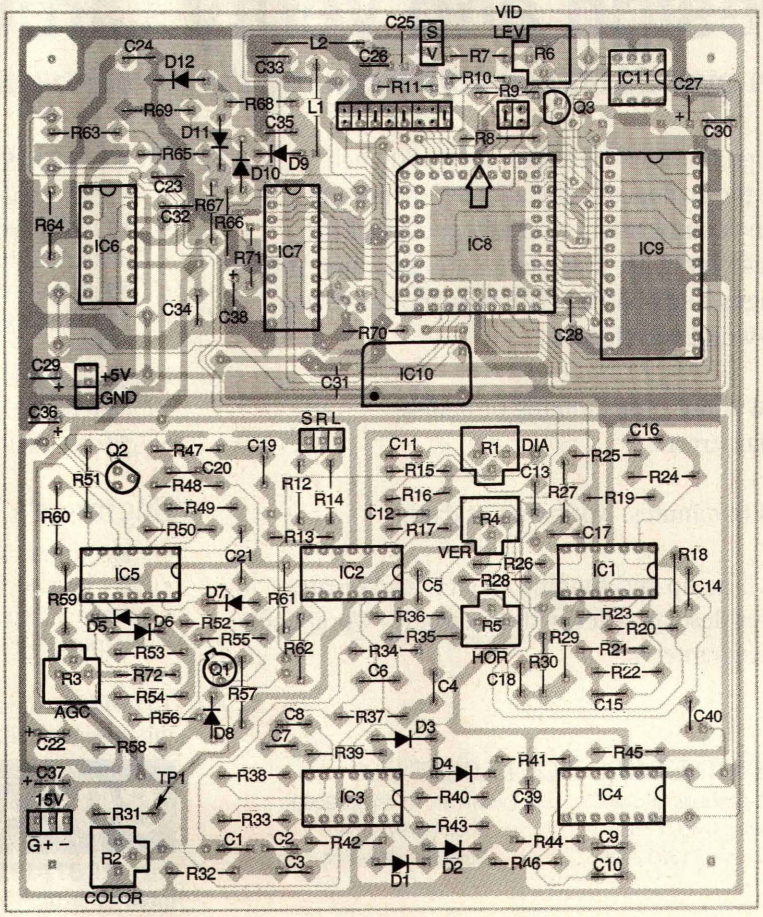
Most telephone equipment will respond to a 60-Hz ring signal. I plan to use a second power transformer, rated for either 24 or 36 volts, with the secondary turns in series with T1, to give a ring voltage of 50 or 60 volts. I still like the "Telco in a Box" because it is a simple, useful circuit. I have already located defects in several telephones with the breadboarded test circuits I have built.

BILL STILES, CET
Hillsboro, MO

When the November "Letters" column mentioned that several eagle-eyed readers had found an error in the "Telco in a Box" schematic, I assumed someone else would have caught another error in the circuit.

The standard for telephone connections states that the red ("ring"") lead is to have negative polarity with respect to the green ("tip") lead. The design shown does not follow this standard. Most recent RJ-11-based devices are designed so they are polarity insensitive. I assume that was done because, as simple as it might be, keeping the polarity correct is not always done. The article clearly illustrates that specific point.

continued on page 23



CORRECTED DIAGRAM for Music Vision article.

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12AX7WA JAN PHILIPS	9.65	7.70	6.50	5.90	5.40	4.90	4.50
12SG7 JAN RCA	1.00	.80	.70	.60	.50	.40	.35
12SH7 JAN GE	1.00	.80	.70	.60	.50	.40	.35
12SL7JAN GE	1.25	1.00	.90	.80	.70	.60	.55
83 JAN GTE	875	7.00	6.40	5.80	5.50	4.90	4.65
829B JAN CETRON	8.55	6.85	6.25	5.65	5.35	4.75	4.50
5656 JAN RAYTHEON	7.50	6.00	5.00	4.20	3.30	2.50	2.20
5750 JAN GE	1.00	.80	.70	.60	.50	.40	.35
5751 JAN GE	6.15	4.90	4.30	3.90	3.20	2.70	2.30
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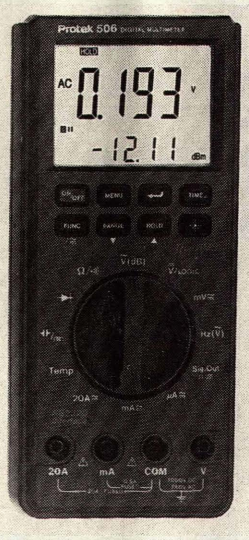

We routinely evaluate new electronic test instruments that have been submitted to us by their manufacturers for review. We then write up our findings in these equipment reports. Needless to say, handheld digital multimeters (DMM) are prominent among the equipment we have reviewed, so when we were offered a new DMM to test, our response was generally ho-hum. However, it turns out that the Protek did come up with an unusual feature to its new 506—an interface for connecting the DMM to a personal computer so you can store, process, and print out measurement data.

Protek's 506 is at the top of its new DMM family that also includes the 504, and 505. The 506 will do everything that the other models will do but it is the only one to offer the RS-232C serial interface that permits the instrument to transfer data to a personal computer. Protek recognized that the PC can supplement the features of its DMM by permitting measurements to be stored, printed out as a data log, or introduced into spread sheets, reports or graphics.

Basic specifications

The Protek 506 is a $3^3/_4$-digit, 4000-count, autoranging DMM with a dual-function liquid-crystal display containing an analog bargraph. It includes a 9,999 (10 MHz)-count frequency counter and annunciators. In addition to its ability to measure all of the basic electrical variables—AC and DC voltage and current (to 20 amperes), and function as an ohmmeter, it provides true RMS readings. Other outstanding features include a ten-location data memory, the ability to measure inductance and capacitance, and a provision to read decibels.

The DMM is packaged a now conventional-appearing, flat, rectangular case with a panel-mounted, 12-position rotary multifunction switch. Eight front panel pushbuttons are assigned to special functions and four panel-mounted jacks accept probes for different measurement scales. The included RS-232C cable plugs into the top of the case. This instrument has a time mode with alarm, clock, and stopwatch, and it can perform min.,max., and averaging. In addition, it can do continuity and diode testing.

The evolving DMM market

The Protek 506 is an excellent example of evolutionary progress in handheld DMMs. In the global electronics market, all DMMs have profited from the decreasing price of components due to increasing demand and production volume, particularly for the crucial integrated circuits that handle the conversion of analog measurements to digital values and the display of that data. The ready availability of the DMM conversion chips and display drivers has turned the DMM into a commodity instrument, if not exactly a consumer electronics product.

To set itself apart from other manufacturers, the DMM maker today must include some unusual feature or features to distinguish his products from the hundreds of look-alikes in all price ranges. This raises two questions: do buyers really want those features, and how much are they willing to pay for them? The marketplace inevitably provides the answers.

From the customer's point -of-view, the DMM, regardless of its country of origin, offers exceptional value in all price ranges. The DMM is arguably the most popular, versatile, and cost-effective instrument available today for the maintenance and repair of electronics. As is true of many other electronics products, the latest DMMs offer more in

continued on page 22

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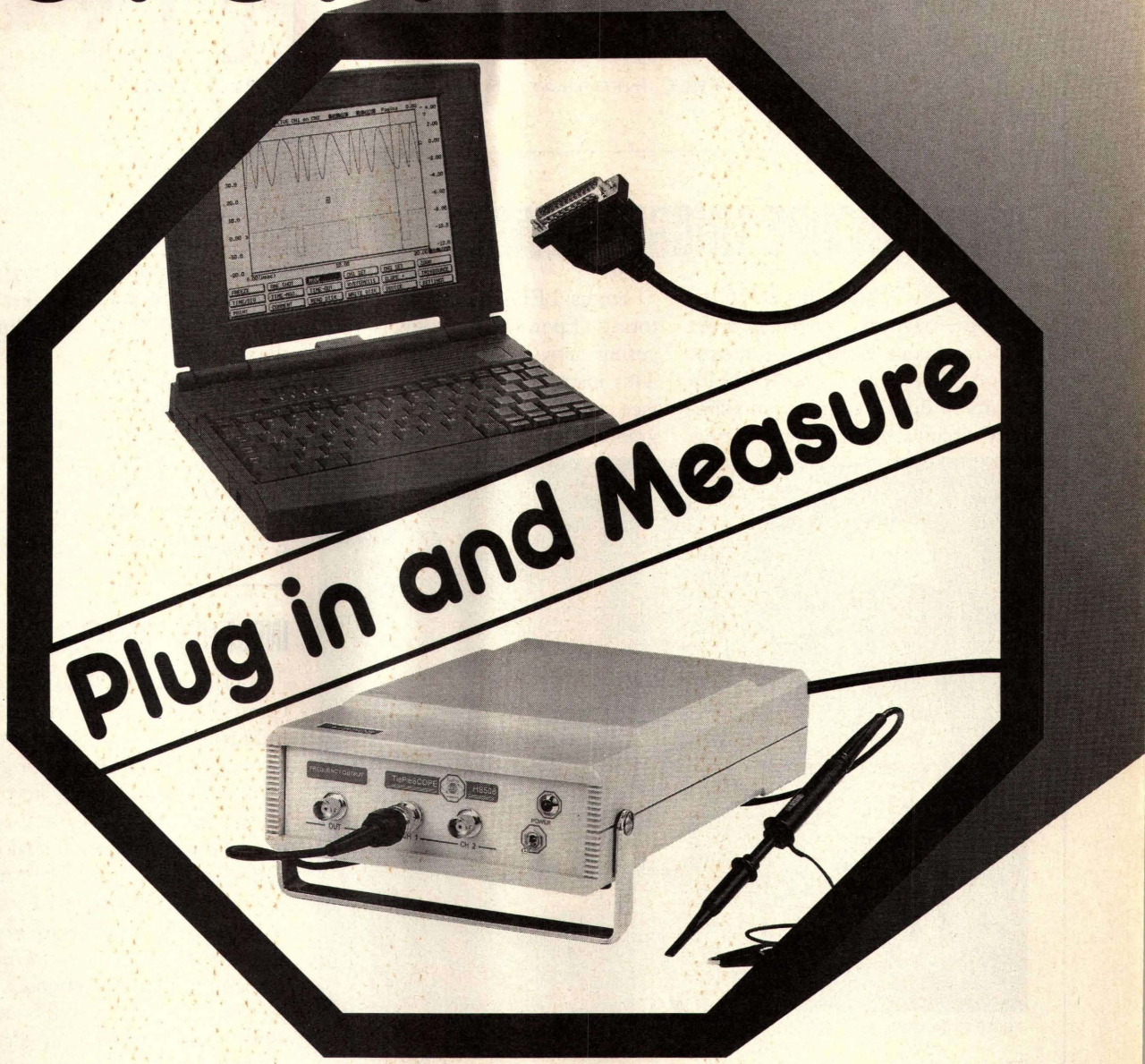

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The SuperProbe II has 18 digital logic inputs and a clock input. It supports three clocked triggering modes and one combinatorial (pattern-match) triggering mode. The device works with flexible logic combinations for specifying triggering events. These include no-match triggering for triggering when certain unexpected events occur. This model has separate "pattern select" and "don't care" configuration DIP switches.

contacts that work with IC clips and 0.025-inch posts.

SuperProbe I is a pattern-match or word-recognition version with 17 digital inputs. It allows any logical combination with up to 17 signals to be specified for the trigger event. This model is offered in two versions. The standard version includes an interface cable with permanently attached grabbers for through-hole component leads. The deluxe version has a cable identical to the one included with the SuperProbe II.

The SuperProbe Basic-8 permits pattern-match triggering with up to eight signal inputs. It includes a cable with permanently attached through-hole component grabbers.

SuperProbe pricing ranges from $99.00 to $549.00, depending on the model.

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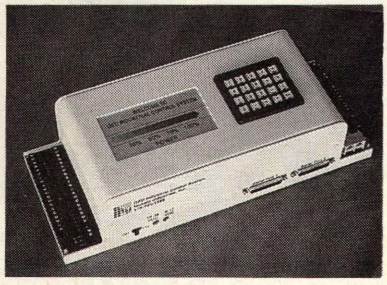
INDUSTRIAL CONTROL SYSTEM

THE QED INDUSTRIAL Control System (ICS) from Mosaic Industries is a single-board computer with either a character or graphics LCD display, and a keypad or touchscreen. It has a battery-backed memory, real time clock, analog and digital I/O, board area for prototyping, and provision for serial communications. The system is packaged in an industrial-style enclosure with screw-terminal connections.

This packaged system is intended for many different applications including machine automation, data acquisition, and robotics. The ICS can interpret data from temperature, pressure, and optical sensors; process the input data; and control stepper motors, valves, relays, and other actuators.



CIRCLE 21 ON FREE INFORMATION CARD

Palm-sized plug-in cards introduce isolated high-current outputs and high-voltage inputs, 4 to 20-milliampere signalling, and analog-to-digital or digital-to-analog conversions. The system modules can be programmed in C or Forth from a personal computer with on-board multitasking software.

The QED Industrial Control System with character display and keypad (ICS-AK) is priced at $995.00. With a graphics display and keypad (ICS-GK), it is priced at $1190.00.

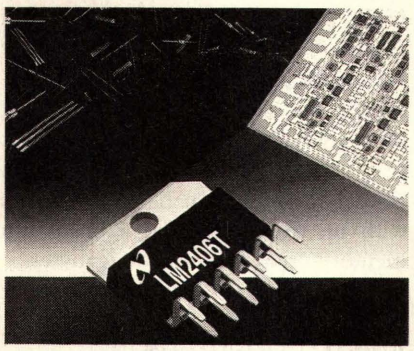
MOSAIC INDUSTRIES, INC.
5437 Central Avenue, Suite 1
Newark, CA 94560
hone: 510-790-1255
Fax: 510-790-0925

MONOLITHIC CRT DRIVER

THE LM2406T FROM NATional Semiconductor is advertised as the industry's first monolithic IC cathode-ray tube driver. This triple-channel, 40-MHz CRT driver, designed for SVGA and XGA monitors. The bipolar device is capable of supporting scan frequencies up to 58 kHz/72 Hz.

The LM2406T can drive a cathode capacitance of 8 pF with a voltage swing of 40 volts peak-to-peak, and it has a rise and fall time of 9 nanoseconds. When paired with National Semiconductor's LM1203N or LM1207N video amplifiers, the combination forms a complete video channel for SVGA and XGA computer monitors.

The monolithic IC includes internal protection to prevent momentary short circuiting. It reduces monitor component count, simplifies system design and manufacture, and increases system reliability .It is offered in a reduced-size TO-220 package.



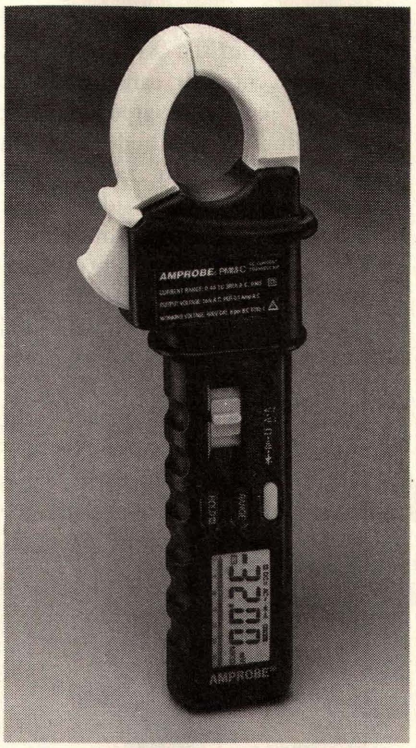
CIRCLE 22 ON FREE INFORMATION CARD

The LM2406T monolithic CRT driver is priced at $2.50 in quantities of 1000.

NATIONAL SEMICONDUCTOR CORPORATION
2900 Semiconductor Drive
Santa Clara, CA 95052-8090
Phone: 1-800-272-9959

MULTIMETER WITH CLAMP-ON ADAPTER

THE AMPROBE MODEL PMM-1 is designed so that a clamp-on adapter can be connected, allowing it to measure up to 300 amperes. The basic DMM is a 3200-count instrument that measures AC and DC voltage to 600 volts and ohms to 30 megohms. It has an annunciated LCD readoutand a 65-segment analog bargraph,. The DMM offers auto and manual ranging, audible continuity testing and data hold. It also performs diode checks The PMM-1 has 600-volt AC and DC protection on all ranges.



CIRCLE 23 ON FREE INFORMATION CARD

With the addition of the PMM-C clamp-on adapter, the PMM-1 can measure up to 300 amperes AC. The adapter jaws will close over conductors up to 1.14-inch in diameter. The combination has an output of 1 millivolt AC per 0.1-ampere AC. With additional optional accessories, thePMM can do infrared scanning and measure up to 1000 amperes AC, 600 amperes DC, temperature, and up to 400 kilowatts.

The PMM-1 digital multimeter with carrying case, test leads, batteries, and a user's manual is priced at $69.85. The PMM-C clamp-on accessory is priced at $49.85.

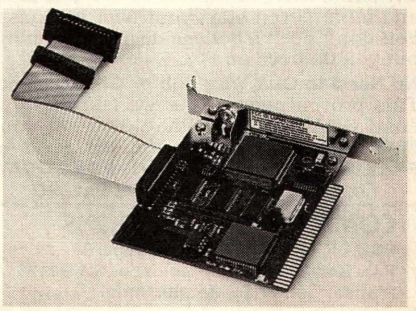
AMPROBE INSTRUMENT
630 Merrick Road
Lynbrook, NY 11563
Phone: 1-800-477-VOLT
or 516-593-5600
Fax: 516-593-5682

COMPUTER CARD FOR MULTIMEDIA PRESENTATIONS.

THE MODEL ME1000 (VGA2-NTSC) plug-in computer card from Methode Electronics allows multimedia presentations to be displayed on a standard television receiver or recorded on a VCR. The card converts VGA computer graphics, computer-aided designs, and multimedia presentations to standard NTSC video output.

The card automatically detects and switches between 640×480 pixel, 320×200 pixel, and 80-column text modes. The plug-in card works with any IBM or compatible personal computer that has an Intel 386, 486, or Pentium processor , an ISA bus, and a graphics card with the appropriate connector.

The ME1000 also provides flicker-free images, CAD-drawing output with no missing lines, and sharp 80-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column text mode. The card conforms to multimedia standards, and it is compatible with AutoCAD and 3D Studio CAD software. It is also compatible with DOS and Windows operating systems. The cards can display 256 colors and are easily installed with the included internal cable.

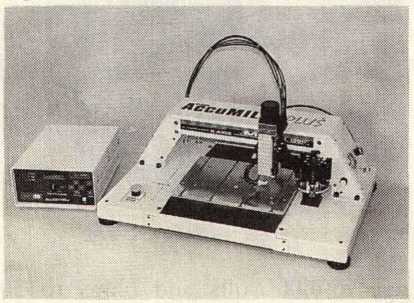
The ME1000 (VGA2NTSC) plug-in card is priced at $525.00

METHODE ELECTRONICS, INC.
dataMate Division
7444 West Wilson Avenue
Chicago, IL 60656
Phone: 708-867-9600
or 1-800-323-6858
Fax: 708-867-3149

DESKTOP MACHINING CENTER

KEPRO CIRCUIT SYSTEMS has introduced the AccuMILL/Plus, a miniature automated X-Y-Z desktop machining center. It can drill, mill, route, and engraves circuit boards. The machine can be fitted with eight different tools. It can drill through both single- and double-sided circuit boards to 0.00025-inch resolution for short-production runs or prototyping. It can also mill circuit patterns and machine complex three-dimensional objects from plastic, aluminum, brass, wood, or modeling wax.

The worktable for the AccuMILL/Plus measures 10×14-inches. Its automated tool carousel has eight tool motors. These include one



CIRCLE 25 ON FREE INFORMATION CARD

fully automatic, fixed/floating position for accurate milling of irregular surfaces. Adjustments can be made to 0.001 inch. The machine has three different motor speeds: 7000, 28,000, or 50,000 rpm. Three-axis mounting of the tools permits the fabrication of three-dimensional parts.

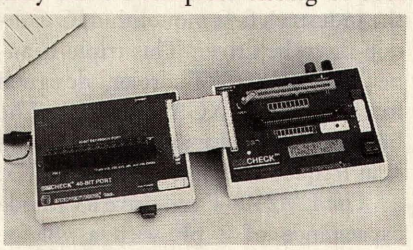
The AccuMILL software package is compatible with AutoCAD, AutoSKETCH, and CorelDRAW. It can interpret ASCII and HPLG plotter-files running under MS-Windows. The AccuSTEPPER controller is an automated computer interface that controls all three axes.

The AccuMILL/Plus desktop machining center is priced at costs xx.

KEPRO CIRCUIT SYSTEMS, INC.
630 Axminister Drive
Fenton, MO 63026-2992
Phone: 1-800-325-3878
Fax: 314-343-0668

MEMORY TEST PACKAGE

THE SIMCHECK PLUS MEMory tester from Aristo Computers combines the SIMCHECK memory module tester with a 40-bit port adapter in a single package. Together, they can do complete testing of both



CIRCLE 26 ON FREE INFORMATION CARD

30-pin and 72-pin single-in-line memory modules (SIMM). The enhanced memory tester includes a universal power supply that can be plugged directly into the tester or into the 40-bit port.

The basic SIMCHECK memory tester tests all standard SIMM and single-in-line (SIP) memory modules with eight or nine bits of 64- and 256-kilobit and 1-, 4-, and 16-megabit memory. The 40-bit port enhances the tester's ability to test 72-pin SIMM modules that have a data bus with up to 40 bits and a maximum memory capacity of 128 megabytes.

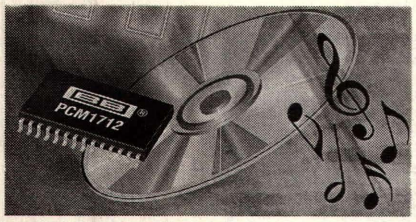
SIMCHECK Plus is priced at $1490.00

ARISTO COMPUTERS INC.
6700 SW 105th Avenue, Suite 300
Beaverton, OR 97008
Phone: 1-800-3-ARISTO
or 503-626-6333
Fax: 503-626-6492

STEREO AUDIO DIGITAL-TO-ANALOG CONVERTER

The PCM1712 stereo audio monolithic IC digital-to-analog converter (DAC) from Burr-Brown includes an 8× oversampling digital filter, a third-order multilevel delta-sigma modulator, a low-pass filter, and an analog output amplifier. It is intended for automotive and consumer electronics products such as CD players, tuners, keyboards, CD-ROM drives, and CD-karaoke systems.

Key specifications for the device include i87-dB THD+N (full scale), 94-dB dynamic range, and 98-dB signal-to-noise ratio. The on-board digital filter has i35-dB stopband attenuation and ±0.17-dB passband ripple. Several special functions are available, including digital attenuation, de-emphasis, soft mute, and double-speed dubbing. The PCM1712 supports both 16-bit normal input data and 16-bit IIS data (32-bits per word, continuous clock).



CIRCLE 27 ON FREE INFORMATION CARD

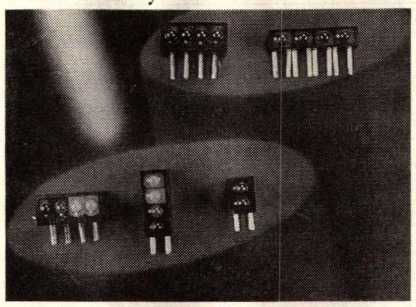
The PCM1712 stereo audio DAC is available in a 28-lead SOIC package, priced from $2.70 each in quantities of 1000.

BURR-BROWN CORPORATION
P. O. Box 11400
Tucson, AZ 85734
Phone: 1-800-548-6132

HIGH-DENSITY PCB LEDs

LUMEX OPTO/COMPONENTS is offering a new series of high-density LEDs that occupy only half the footprint of standard T-5 LED packages. Consequently, more LEDs can be positioned in limited circuit board space. The new devices feature foolproof polarity orientation. They are intended for such applications as function indicators, circuit board fault indicators, and front-panel display backlights.

The LEDs are available in four configurations: two-vertical (dual-tower), four vertical (quad-tower), and four horizontal(quad-ranch) with either side-by-side or front-to-back leads for PC-board connection.



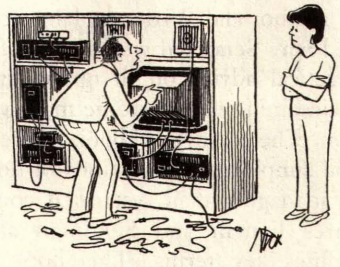
CIRCLE 28 ON FREE INFORMATION CARD

The shape of the lenses assures proper polarity orientation. Round and a square flanges around the leads assure proper placement of the LEDs in their compact holders during assembly. The LEDs' 2-mm size and a space-saving holder eliminates spacing between LEDs for high-density installations. Variations in the doping of the LED dies provides high-intensity red, red, yellow, amber, green and even blue. The configurations are available in any color combination, in either standard or low-current models. The LEDs draw from 2 to 20 milliamperes

The Lumex LEDs are priced from $.50 to $4.00 per configuration, depending on the number of LEDs, colors, and quantities ordered.

LUMEX OPTO/COMPONENTS INC.
292 East Hellen Road
Palatine, IL 60067
Phone: 708-359-2790

EN



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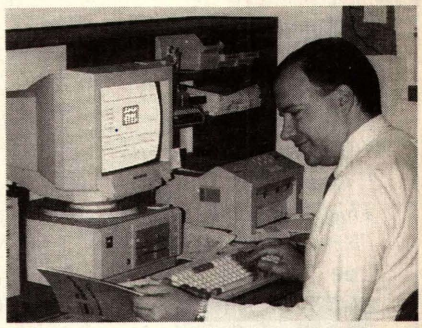

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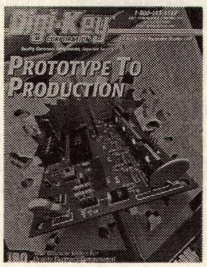


CIRCLE 337 ON FREE INFORMATION CARD

Mail-order distributor Digi-Key offers more than 1400 new products from 15 different manufacturers in its latest catalog. Newly introduced products include ribbon-cable and D-type subminiature connectors from AMP, Inc., power supplies from Power-One, microcontrollers from Microchip, and development systems from Picmaster.

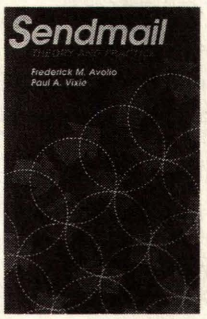
A Quick Index on the first page will speed up finding references to the products being offered. This is supplemented by detailed manufacturer and product indexes. Digi-Key sells just about everything a manufacturer or serious electronic hobbyist needs and its catalog is a valuable reference for the professional designer as well as all advanced hobbyists.

The catalog is arranged alphabetically by manufacturer with alphabetical tabs on the outside edges of the pages for quick reference. A comprehensive index both by product and by manufacturer makes it easy to find what you are looking for in this huge 368-page compendium of electronic parts.

Digi-Key's product line card includes all the basic passive electronic components, discrete and integrated semiconductor devices, and connectors and cable assemblies and much more. The company offers hand tools, soldering materials, power supplies, and a wide variety of test equipment in addition to all the active and passive component lines that it lists.

Sendmail: Theory and Practice

by Frederick M. Avolio and Paul A. Vixie.
Digital Press
313 Washington Street
Newton, MA 02158-1626
Phone: 617-928-2500
Fax: 617-928-2620
$29.95



CIRCLE 338 ON FREE INFORMATION CARD

This book explains the history, architecture, configuration, and maintenance of Sendmail, a standard mail deliverer on Berkeley-Unix systems. Widely used on the Internet, many consider Sendmail impossible to understand. The authors have tried to correct that.

Avolio and Vixie explain how and why Sendmail works and offer practical advice on designing and maintaining an electronic mail system. There are "cookbook recipes" and simplified explanations of how to manage a mail system. It compares E-mail and Sendmail and defines key terms. This book is great for computer system managers and readers who want to set up and maintain a mail system for computers.

Hipercomm Databook (BR1334/D)

Motorola Inc.
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P. O. Box 20924
Phoenix, AZ 85063
Phone: 1-800-441-2447
Fax: 602-994-6430
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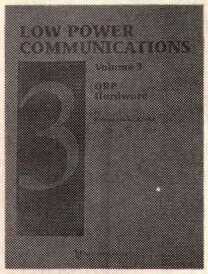
CIRCLE 339 ON FREE INFORMATION CARD

This is a revised edition of Motorola's Hipercomm Databook. It contains device specifications in the form of data sheets and applications information for Motorola's frequency-control products. It contains technical data on a broad line of integrated circuits for phase-locked loop circuits. An introductory section simplifies the selection of the right components for a given set of applications requirements.

Motorola's line of low-power prescalers includes products with more than 40 different combinations of frequency, divide ratio, and power to meet the needs of most designs. Information is also included on Motorola's integrated, single-chip synthesizers that conserve power, making them suitable for handheld, battery-operated communications products.

Low Power Communications

Volume 3: QRP Hardware
by Richard Arland, K7YHA.
Tiare Publications
P. O. Box 493
Lake Geneva, WI 53147
Phone: 1-800-420-0579
$14.95



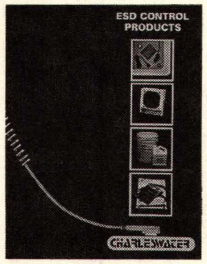
CIRCLE 340 ON FREE INFORMATION CARD

This is the third volume of three in a series on QRP, an international radio Q signal that means "reduce your power". Previous titles were "QRP Basics" and "Advanced QRP Operating." This book on low-power communications examines the new and used equipment available for the radio amateur who is planning to upgrade a QRP station that might be communicating with microwatts of power. It includes tips on buying and trading used equipment, and discusses operating accessories of value to the QRP operator.

Arland's book includes a chapter on the planning and erection of antenna towers and another on how to start and run a QRP club. The addresses of QRP clubs and suppliers and manufacturers of QRP equipment are listed in the appendix.

ESD Control Products.

Charleswater
90 Hudson Road
Canton, MA 02021-1407
Phone: 617-821-8370
Fax: 617-575-0172
free



CIRCLE 341 ON FREE INFORMATION CARD

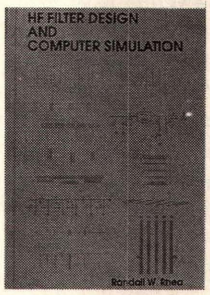
This is the latest catalog from Charleswater on its products for the control of electrostatic discharge (ESD). Many new ESD control products and training aids are included. It also provides up-to-date information on existing product categories.

Charleswater's product line does include all of the standard accessories necessary to EDS-proof a designated ESD-protected workstation: conductive workplace mats, grounded wrist straps, conductive floor mats, and instruments for testing the integrity of the ground. Also included are conductive tote boxes, protective bags and packaging for vulnerable components and circuits, air ionizers, and conductive sprays.

This catalog also includes a basic tutorial on electrostatic discharge, explaining what it is and how it is controlled by grounding, shielding, and moving-air neutralization.

HF Filter Design and Computer Simulation

by Randall W. Rhea.
McGraw-Hill Book Company
11 West 19th Street
New York, NY 10011
Phone: 1-800-2-MCGRAW.



CIRCLE 342 ON FREE INFORMATION CARD

This book is a complete design guide for printed and LC filters for RF and microwave applications. It includes easy to understand discussions of high-frequency filter theory and accurate computer simulation models for many different filters. Rhea's book includes a review of the classic design formulas as well as the more recent filter design concepts developments.

The first chapters are devoted to fundamental concepts, with greater emphasis given to lumped-elements than distributed elements. Those chapters are followed by a review of available computer-aided filter-design techniques, including both simulation and synthesis.

The author goes on to discuss distributed low-pass, bandpass, high-pass, and bandstop filters, and he explains how to select the appropriate design for specific applications. EN

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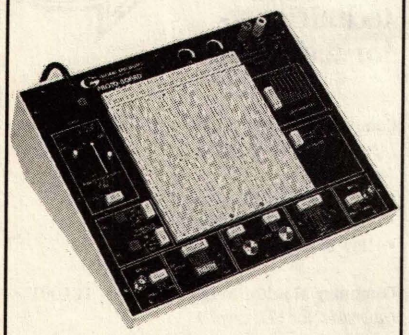

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EQUIPMENT REPORTS

continued from page 14

terms of accuracy, reliability, power conservation, and performance features than did the earlier generations of those products.

The hard fact is that the reliability of the manufacturer or supplier is more important than the county of origin in any purchase decision for a DMM. If the product fails for some reason, can it be repaired economically? Will the vendor stand behind product warranties, or must you throw away the instrument and buy a new one if it conks out?

The DMM market today is stratified, and regardless of where it is made, you get pretty much what you pay for. As in the past, DC accuracy and resolution are all important considerations, despite such attractive features as larger displays or more rugged packaging. Handheld DMMs, like personal computers and other consumer electronics products, have been stuffed with more features with little or no price change.

Open any electronic equipment catalog, visit your local electronics store, or look at the ads in *Electronics Now*, and you'll see 3-digit handheld DMMs priced as low as $20 and those with $3^3/_4$-digit readouts and 0.1% DC accuracy priced at $200 or higher, with a slew of options in between. Thus, prudent buyers will examine and compare features, check out the reputation of the supplier, and make their decision based on thier actual needs today and consider their future measurement requirements.

More on the Protek 506

The Protek 506 DMM is top of the line in a family of three new multimeters that also includes the 504 and 505. It offers 0.3% DC voltage accuracy. The software included with the 506 to support its RS-232C serial interface allows all functions and measurements to be viewed both on the meter and the computer screen simultaneously. The $3^1/_2$-inch diskette included with the meter contains the software for Windows and MS-DOS.

In addition to its 20-ampere measurement capability, the Protek 506 can measure current values to 400 microamperes with 0.1-microampere resolution. The autoranging feature can also be turned off, and each range can be set manually. The DMA's light-emitting diode backlight can be turned on and off with a panel pushbutton to conserve the 9-volt battery. Backlighting is especially useful at night or in locations where normal room lighting is inadequate.

The Protek 506 includes a built-in timer with an alarm that is displayed on the secondary display. The timer can count up to or down from periods up to 10 hours. This feature allows you to make periodic measurements without constantly referring to a clock or watch.

Temperature from −20°C to +1200°C, with 1-degree resolution, can be measured with an optional K-type thermocouple. The thermocouple can be connected with an adapter to the meter's test lead jacks. Temperature in degrees Celsius is shown on the main display and temperature in degrees Fahrenheit is shown in the secondary display.

The 506 can be set to produce a 5-volt peak-to-peak squarewave at three different frequencies: 2048, 4096, and 8192 Hz. Thus, squarewaves at different frequencies can be introduced into circuits under test or for the testing of audio devices such as buzzers, speakers, and transducers. The meter will automatically turn off its power after it has been idle for 30 minutes if you forget to turn it off. However, this feature can be disabled if you must have the power on for more than 30 minutes. The instrument includes overload protection and safety design in compliance with UL 1244 and VDE-0411.

The Protek 506 is definitely in the professional instrument category. However, although it was designed for the professional, its price is low enough to attract the serious hobbyist. The model 506 including carrying case, manual, test lead, 9-volt battery, RS-232C cable, and diskette is priced at $189.95. (Protek, 154 Veterans Drive, Northvale, NJ 07647, 201-767-7242.) EN

LETTERS

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However, there is still a lot of older serviceable telephone equipment around that can be tested with the "Telco in a Box." As shown, the circuit will indicate polarity sensitivity (primarily DTMF, or AT&T's TouchTone) to be defective; they will work but will not produce any DTMF. There are DC-operated circuits that depend on the loop current for power. Thus, reversing the polarity is like putting batteries in a radio with their positive and negative terminals reversed.

All that is required to make a telephone polarity insensitive is to design a diode-bridge circuit within the telephone in the tip and ring so that the positive and negative polarities will be correctly delivered to the circuitry, regardless of what the loop polarity is.

JIM DOPSON
Lilburn, GA

DEFENDING THE AMIGA

I am responding to the appalling opening paragraph in Don Lancaster's description of the New Tek toaster ("Hardware Hacker," *Electronics Now*, August 1995). He stated that Amiga was "left in a less-than-stellar position after the sale of Commodore." He also said that an internationally known company in bankruptcy court sold its assets at a "yard sale." But to say that the company threw out the baby and drank the wash water was reprehensible. However, it is true that the transaction was bizarre.

The facts are that New Tek wanted to enter the personal computer market, so it made a PC version. Why did Lancaster have to trash the name Amiga along the way? Commodore was purchased by EsCom, a large company with extensive financial resources and a large distributor base in place. The company intends to continue producing and selling the Amiga. It also has plans to sell rights to the Amiga so it can be cloned. Amiga's future is brighter now than it has been in years.

continued on page 47

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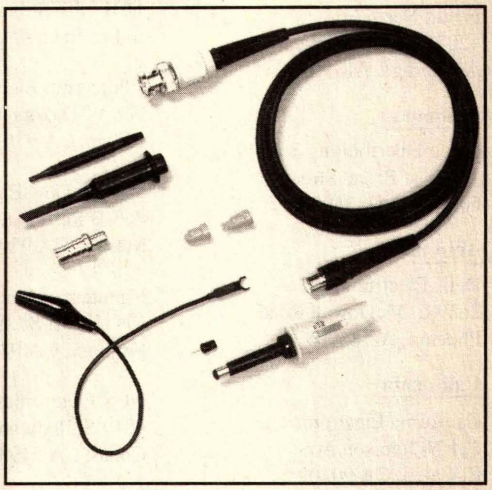

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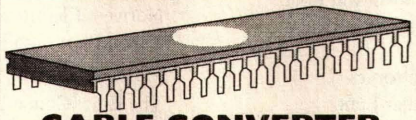

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LOW-COST SOFTWARE for PC-BOARD DESIGN

You can design professional-quality printed-circuit boards on your desktop PC.

TJ BYERS

THE JOB OF DESIGNING A PRINTED circuit board continues to grow more demanding. In the past, just about anyone could lay out a PC board by simply reading a schematic and translating the lines into traces on a piece of metal-clad circuit board with a resist-ink pen or dry-transfer decals and tape. Those days are all but gone. Today's circuit boards are made by powerful CAD systems that include many built-in features for design optimization and design-rule checking. Until recently, though, capable circuit design packages were priced out of the range of most hobbyists and many small businesses. Fortunately, that situation has changed, too.

This article looks at twelve PC-board layout software packages that are designed to run on your desktop IBM-compatible personal computer. Each package costs less than $350. Most of the programs are linked in one way or another to the schematic-capture programs reviewed in the September and October 1995 issues of *Electronics Now*. A couple are standalone PC-board layout programs, and one, TurboCAD, is a general-purpose CAD program running with a PC-board component library.

As before, we tested the programs to see how they compare in price, ease of use, and features by producing a board based on a benchmark circuit. Fig. 1 is the schematic drawing of that circuit, which is a functional MIDI interface box for a Sound Blaster (and compatible) sound board. This design was selected because it provides a good mixture of analog and digital ICs, plus an assortment of connectors—the latter of which is extremely difficult for the software to deal with in terms of library support and layout flexibility. In fact, the connector had to be created or modified in nearly half the programs, which gave us an opportunity to examine the library editor or netlist editor. Finally, each program was printed out and the hard-copy or data file was examined for accuracy and production quality.

PC-board Layout Software

As with schematic capture software, the "devices" needed to build a printed-circuit board are contained in a component library. Basically, a PC-board device is a collection of circles and ovals, called pads, that have the same pattern as the part that will be soldered to them. These patterns are often called footprints because they can be used for many devices with the same pattern—a 14-pin DIP, for example—regardless of their electrical properties.

Most circuit designs are too complex to be constructed using a single layer of copper. Most hobby projects require two layers (top and bottom); many commercial designs need four layers or more. Very often these layers have to be wired together to maintain electrical continuity. This is done using vias (see Fig. 2). When the via goes all the way through the board from the top to bottom, it's called a through-hole via. As a rule, through-hole vias are used as solder points for resistor, capacitor, and IC leads. Vias that connect one layer of a multi-layer design to the layer just below it is called a blind via. Blind vias that occur within the bowels of a multi-layer PC board are called buried vias. The size and shape of the via is critical to the success of a layout. Generally, the more via options, the better.

Tracks come in many different shapes and sizes, too. Unlike vias, tracks aren't a part of the component library (note the TurboCAD exception). Instead, they are placed on the board using pens with differently "shaped" tips. Different track widths can usually be mixed on the board—at least up to a point. For production reasons, it's desirable for tracks to have rounded or chamfered corners instead of right-angle turns. Most PC-board layout software lets you change copper layers while routing to avoid roadblocks caused by tracks that are already in place; each uses a different mechanism, as detailed below. Ideally, a via should be automatically placed when changing layers. The term "neck down" refers to the ability to change the width of the track as you draw it. However, in programs costing this little, necking down, when available, is usually done afterwards using the track editor. The ultimate in

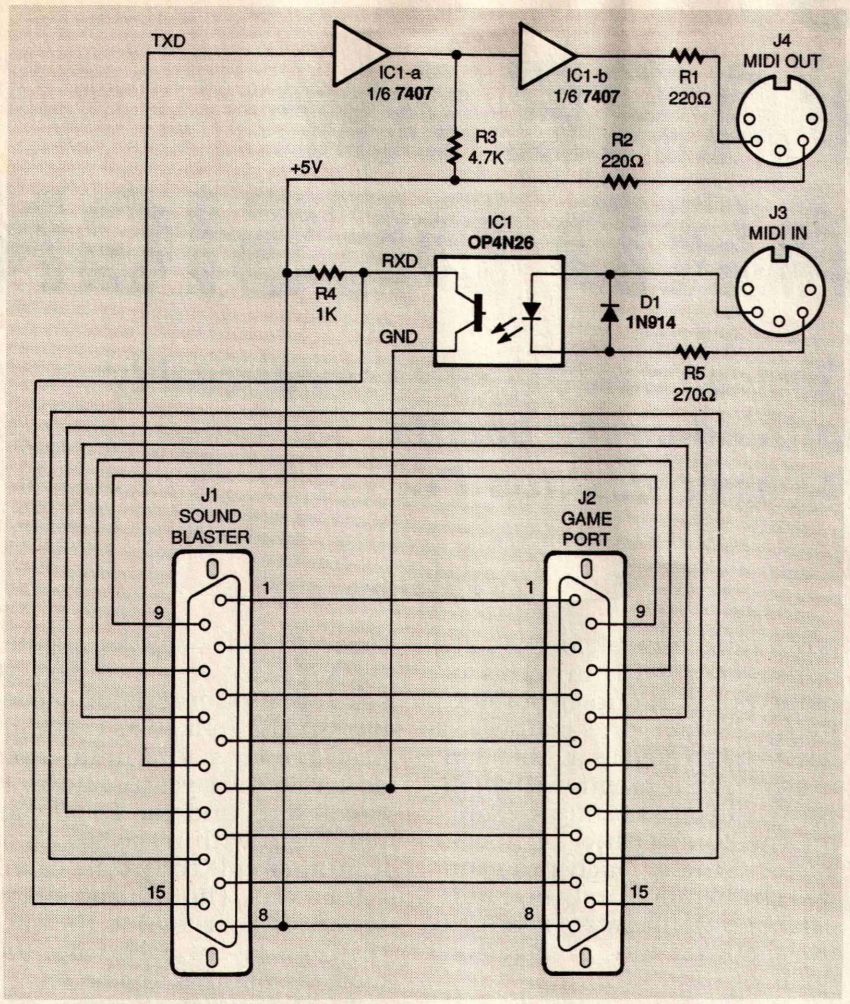


FIG. 1— THIS IS THE ELECTRONICS NOW BENCHMARK circuit used for testing the PC-board layout programs in this review. It is a functional MIDI interface box (J3 and J4) with support for a game port.

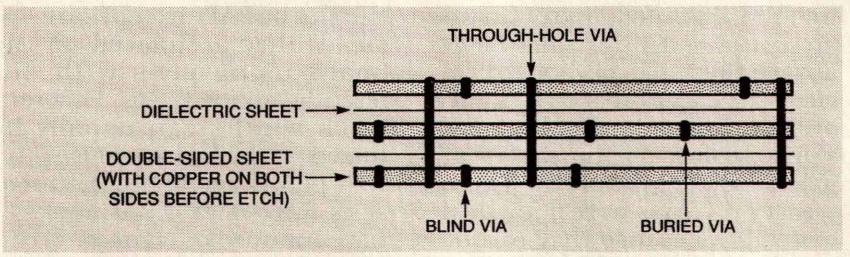


FIG. 2 — MULTI-LAYER BOARDS are typically manufactured as stacks of two-layered boards. For example, a six layer board is made up of three two-layer boards, which are etched first and then bonded together. Vias make connections between the layers.

routing, of course, is an autorouter. Two of the programs here have an autorouter—one a full autorouter and the other a pad-to-pad autorouter—and two more have an autorouter option at extra cost.

There are two types of PC-board layout programs, those that stand alone, and those that are linked to a schematic capture program via a netlist. Of the programs discussed here, only four have a netlist connection, although eight of the programs are associated with a schematic capture package.

PC-board Layout

The following four PC-board layout programs are stand-alone software packages. They range in cost from free to $129, and are best used for projects where the component count is low, to reduce wiring errors, or where there's a repetition of a pattern, such as in a memory module with many identical ICs.

Product:	Easytrax
Version:	2.06
Price:	Free
Platform:	DOS
Publisher:	Protel Technology

Although there might not be any such thing as a free lunch, Easytrax from Protel Technology is as close as you'll ever come to it. Easytrax is a fully-featured, DOS-based PC-board layout program from Protel Technology which originally sold for $450 and is now available absolutely free. Yep, you heard right. It's freeware! And we're not talking about an obsolete, second-rate program here. Easytrax, the introductory-level member of the Protel family of Electronics Design Automation (EDA) packages, puts professional-quality PC-board layout tools in the hands of students, hobbyists and part-time designers for the cost of a phone call. (See Fig. 3.)

Easy to learn and easy to use, Easytrax can construct PC Boards up to 32-inches square with up to eight layers of copper. Easytrax works on the complete range of IBM PC/XT/AT, PS/2, and compatible computers—plus it can run from floppies as well as a hard disk. The program is supplied with graphics drivers that support video resolutions of up to 1024x768 and 16 colors, though most of the video boards supported are long obsolete. Fortunately, you can download the graphics driver source code from the Protel bulletin board (408-243-0125), which tells you how to write your own graphics driver.

Like many PC-board layout programs, everything on the board is put there by hand, one part or one track at a time. The software doesn't interface with any schematic capture program or any type of netlist.

The Easytrax component li-

continued from page 121

So, You Want to Buy a New Computer?

To be a smart computer shopper, you have to speak the language!

TJ BYERS AND NAOMI WISE

EVEN IF YOU RARELY WATCH TV, you've probably seen the commercial in which a pair of elderly Frenchmen stroll on the banks of the Seine chatting—not about their health, but about their computers' storage capacities. They conclude that only lasers can fulfill their deepest desires. This IBM advertisement has English subtitles. But even the subtitles can seem to be in a foreign language unless you're computer-savvy enough to know that they're talking about CD-ROMs.

If TV advertisements such as those in IBM's "Solutions for a Small Planet" campaign are mildly baffling, print advertisements and live computer salespeople often speak an even more arcane dialect, slinging around jargon like "ASPI" and "RISC" until even veteran nerds can feel bewildered. Unless you understand the language like a native, you're at the mercy of salespeople to translate the computerese for you. Unfortunately, even technically knowledgeable people can find themselves out of touch with new computer terms unless they make a conscious effort to keep up. If you understand the terms, you can make up your own mind as to what you really need when you buy a new computer—and what fancy features you can easily forego.

The CPU

The most important consideration in choosing a computer is what type of central processing unit (CPU, processor, or microprocessor) it should have. The CPU determines how much your system will cost and how fast your applications will run. CPUs are usually referred to not by names, but by numbers that are a sort of shorthand indication of their speed, power, and capabilities. The CPU's speed isn't the same as its power, however. For example, a 100-MHz 486DX4 can't perform as fast as a 60-MHz Pentium. Today, most PCs run Intel's Pentium or i486 CPUs, or clones of those devices.

The i486 processor. The i486 family of processors, invented by Intel and now cloned by AMD and Cyrix, is the workhorse of the industry. The group includes the 486SX, 486DX, 486DX2, and 486DX4. The SX and DX chips are identical in every way, except that the DX processors have a built-in floating-point unit (FPU) math coprocessor, and the SX chips don't.

All 486 processors have an external bus width of 32 bits. (A bus is multiple parallel conductors that transfer data between components of a computer system so that they can work together.) The speed of a 486 processor is the rate at which the chip's internal electronics run, which is not necessarily the same as the speed of the motherboard. Older processors, such as the 486SX and 486DX, run at the same speed as the motherboard. The newer processors have clock-doubler (DX2) or -tripler (DX4) circuitry to synchronize the CPU's internal clock with the motherboard's clock, so they can run at twice or three times the speed of the motherboard. (Note that despite its moniker, the 486DX4 doesn't run at four times the motherboard's clock, but three times instead.) The chips' designations (for instance, 486DX2-66, 486SX2-66) reflect the presence of the clock-multiplier.

The members of the 486 family have a 64-bit internal architecture, so they can process instructions and data 64 bits at a time. However, they have only

a 32-bit interface. This is why these CPUs are not always as fast as their names make them sound.

Pentium power. The next step up in power is Intel's Pentium series. Unlike the i486 processors, Pentium chips support an external 64-bit interface, lending a noticeable gain in speed and power. The new architecture also makes full use of *superscalar* programming code that executes two or more instructions per clock cycle as opposed to one instruction per cycle for the i486 series.

Pentiums have six family members divided into two groups: the first consists of the 60-, 66-, and 75-MHz processors. The second group consists of the 90-. 100-, and 133-MHz processors. The 90-, 100- and 133-MHz Pentium processors are not only faster, but they include special features to manage power for "green" operation and to speed up communications between components. Intel has solved the Pentium's little math problem that you might have heard about, so it's unlikely you'll need to worry about chip-based arithmetic errors.

Intel alternatives. NexGen's Nx586 CPU is a low-cost Pentium alternative that's making waves in the mainstream PC market because its 32-kilobyte cache is twice that of the Pentium and four times that of the 486. The bigger a CPU's built-in cache, the faster many applications run (see Table 1). NexGen's RISC processor is 100 percent compatible with all Intel-based processors from the 8088 through the Pentium, and it runs a tad faster than a Pentium processor of equal speed. Unfortunately, it doesn't have a built-in math coprocessor, though it does support an external one.

Popping up frequently in computer ads is the PowerPC, a CPU that was developed jointly by Apple, IBM, and Motorola. PowerPC models (which range from energy-conserving units suitable for laptops, through those for desktops and on up to high end workstations) include superscalar microprocessor design that can perform three to four instructions per clock cycle.

Power-PC based systems are also DOS-, Windows-, and Macintosh-software compatible, so if you've got a Mac in the office and a PC at home (or vice versa), you can take your work home and slave around the clock without incompatibility hassles. The manufacturers claim that the PowerPC is faster than a Pentium. However, only the very few applications written specifically for the Power PC run rapidly. Other programs shuffle along in an emulation mode, at about the same poky pace as they'd run on an old 386.

Far faster and more powerful (and costly) are the Alpha and R4000/R4400 processors. Touted as the fastest desktop processor on earth, the Alpha chip from DEC (Digital Equipment Corp.) blasts off at a sizzling 275 MHz. The more conservative R4000/R4400 CPUs from MIPS run at a tamer 150 MHz.

All three of these devices are RISC processors. However, like the PowerPC, these rockets reach escape velocity only with the few programs that, as yet, have been designed especially for them. However, a special version of Windows NT, called Windows NT 3.5 Workstation, lets you run your present library of DOS and Windows software on computers based on these RISC microprocessors at about twice the speed of a 60-MHz Pentium.

Continued on page 139

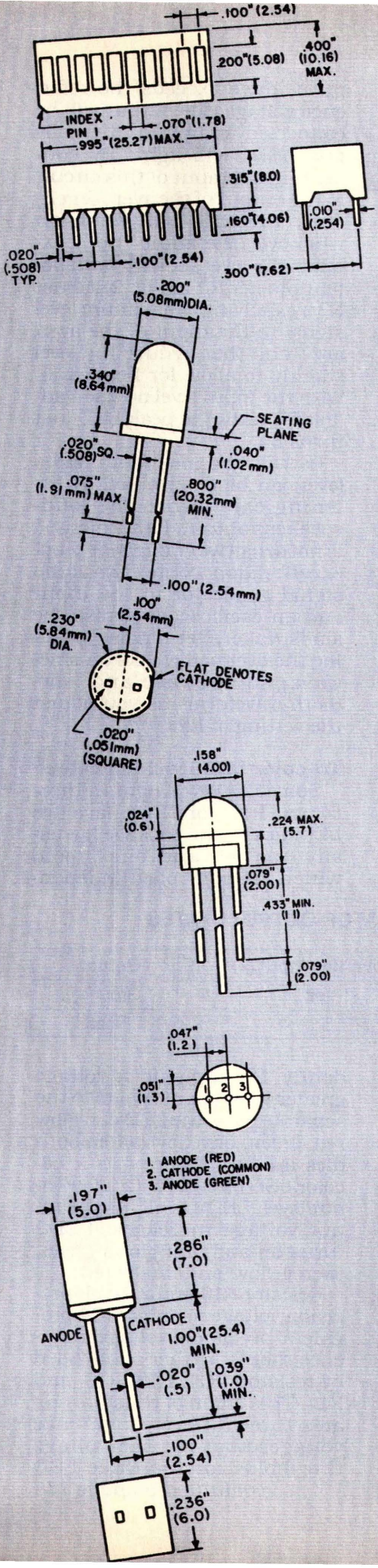
TABLE 1—CPU COMPARISONS

CPU	Data Bits	Top Clock Speed	Cache Size	Math Coprocessor
DEC Alpha	64	275 MHz	—	yes
R4000/R4400	64	150 MHz	—	yes
Pentium	64	100 MHz	16K	yes
NextGen Nx586	64	90 MHz	32K	external
PowerPC	64	110 MHz	32K	yes
486DX4	32	100 MHz	8K	yes
486DX2	32	66 MHz (1)	8K	yes
486SX2	32	66 MHz (1)	8K	no
486DX	32	50 MHz	8K	yes
486SX	32	33 MHz (2)	8K	no

1) AMD 486DX2 and 486SX2 chips run at 80 MHz.
2) AMD 486SX chips run at 40 MHz.

TABLE 2—OPERATING SYSTEM COMPARISONS

Operating System	Windows 95	Windows NT	O/S2 Warp	Windows 3.1	DOS 6.22
Minimum Ram Required	8 MB	8 MB	4 MB	640 K	90K
Disk Space Used	60 MB	66 MB	40 MB	6 MB	5 MB
Password Security	Y	Y	Y	N	N
Runs DOS Applications	Y	Y	Y	Y	Y
Runs Windows Applications in Real Mode	Y	N	Y	Y	N
Runs Windows Applications in Standard Mode	Y	Y	Y	Y	N
Runs Windows Applications in Enhanced Mode	Y	Y	Y	Y	N
Runs 32-bit Applications	Y	Y	Y	N	N



Dress Up Audio Projects

With Solid-State Level Indicators

ROBERT C. RICHARDS

THE D'ARSONVAL (MOVING NEEDLE) analog meter has been the instrument of choice for setting input levels in audio systems for years. Now that most audio equipment has been miniaturized an analog meter will no longer fit on the front panel of the equipment.

This role has been filled by light-emitting diode circuitry. Solid-state level indicators based on a string of LEDs instead of a moving-coil meter are now included in most consumer audio products: from tape decks to baby monitors. They are small, lightweight, inexpensive, and immune to shock damage that could damage an analog meter's delicate meter movement.

This article describes three different methods for adding solid-state LED level indicators to your audio projects. In each, the level indicator selected gives the equipment a more professional appearance than in the original project while providing a useful function.

Typical amplifier

Figure 1 is a block diagram of a typical audio amplifier. The input signal is applied to an adjustable-gain amplifier stage. This first stage raises the voltage of the input signal to a higher audio level for the power amplifier stage, and the amplifier's gain is controlled by the operator with a front-panel knob. The output of this first stage is fed to a power amplifier that drives a loudspeaker. The gain in the adjustable amplifier stage must be high enough to allow the signal from the loudspeaker to be heard after the power amplifier has been amplified. However, this gain must not be so high that the signal becomes clipped and distorted. There is also the possibility that the loudspeaker could be damaged if it is overdriven.

The level indicator circuit shown in the dashed box (Fig. 1) is useful in alerting the user that the gain of the adjustable amplifier is set improperly. This circuit consists of a signal-averager stage that clips audio signal peaks for a smooth display and an LED level indicator display consisting of from one to ten LEDs. By observing this LED display, the operator can adjust the amplifier for minimum distortion and proper operation.

Signal averager

The signal averager circuit in Fig. 2 will be shared by all of the LED level indicators described in this article. The operational amplifiers are general purpose types. The TL072 dual operational amplifier will save PC board space, and it is a reliable, inexpensive, medium-quality device. The first operational amplifier, IC1-a, is an inverting amplifier whose gain can be adjusted up to 5. Adjustable feedback resistor, R2, sets the circuit gain. It is a PC- board-mounted trimmer that is set once and never adjusted again.

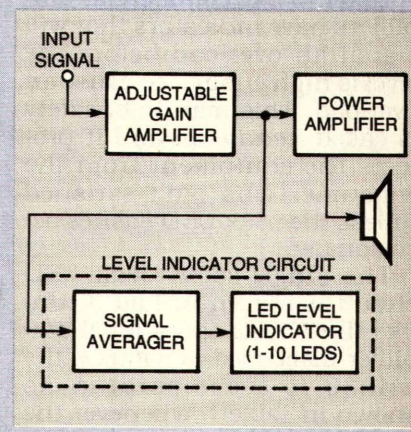


FIG. 1—A TYPICAL AUDIO AMPLIFIER block diagram with a LED level indicator circuit added.

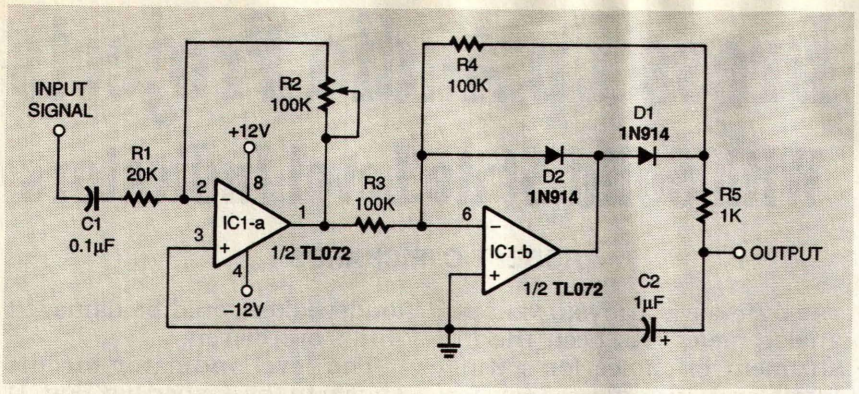


FIG. 2—A SIGNAL-AVERAGER circuit for use with the LED level indicator circuits discussed in the text.

This gain stage links a specific input voltage level to a specific LED indicator.

The second operational amplifier, IC1-b, forms a half-wave rectifier and signal averager that clips the brief peaks and displays them over a longer period of time. By stretching out and smoothing those peaks, as seen on the LED-level display, it will be easier to set the input adjustable-gain amplifier, IC1-a.

One-color LED peak indicator

The simplest solid-state level indicator is a single LED that flashes ON when the input level is high enough to drive the remaining audio stages. However, if you install only one LED, it is more important that it be used to alert the operator to an overload condition. The input level can then be reduced to avoid signal clipping and distortion. It can also reduce the possibility of damage due to excessive heat in the power amplifier and speaker. Most commercial amplifiers have indicators that will signal an overload before the level is high enough to cause an overload. This margin of safety is called *headroom* and it protects the equipment from the consumer who isn't satisfied unless the peak LED flashes occasionally.

The single-color, peak LED circuit is shown in Fig. 3. Unlike the TL072 operational amplifier discussed previously, the LM339 is a comparator. As shown in Table 1, whenever the voltage at the inverting input (labeled "–") of the LM339 is higher than the voltage at the noninverting input (labeled "+"), the output of the comparator is internally grounded. However, whenever the voltage at the inverting input is lower than the voltage at the noninverting input, the output of the comparator floats (effectively an open circuit) and no current flows.

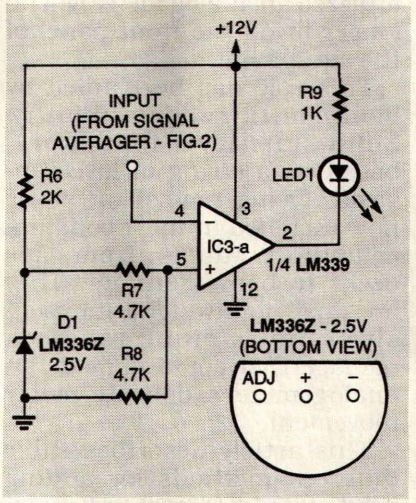


FIG. 3—A SINGLE-COLOR LED peak indicator circuit.

The voltage divider consisting of resistor R6 and 2.5-volt precision voltage reference IC2 form a precision voltage reference whose voltage is divided in half at the junction of resistors R7 and R8. This places a reference voltage of 1.25 volts at the comparator noninverting input. Whenever the inverting input voltage exceeds the reference voltage, the output will be connected to ground internally and LED1 will light. By connecting the input of this circuit to the output of the averager circuit, the LED will flash on whenever the audio input exceeds the level set with gain potentiometer R2 in Fig. 2. Adjust R2 by applying a maximum level signal to the input of the averager, and then reduce the level slightly to allow for headroom. With the input level now set, adjust R2 until the peak LED just turns on.

Usually the maximum audio level can be determined by listening carefully to the loudspeaker's output. If this method is not sensitive enough for proper calibration, connect an audio signal generator to the input and an oscilloscope across the loudspeaker's terminals. Examine the overload effects on sinewave, squarewave and sawtooth-waveforms as you adjust the setting of R2.

Tri-color LED level indicator

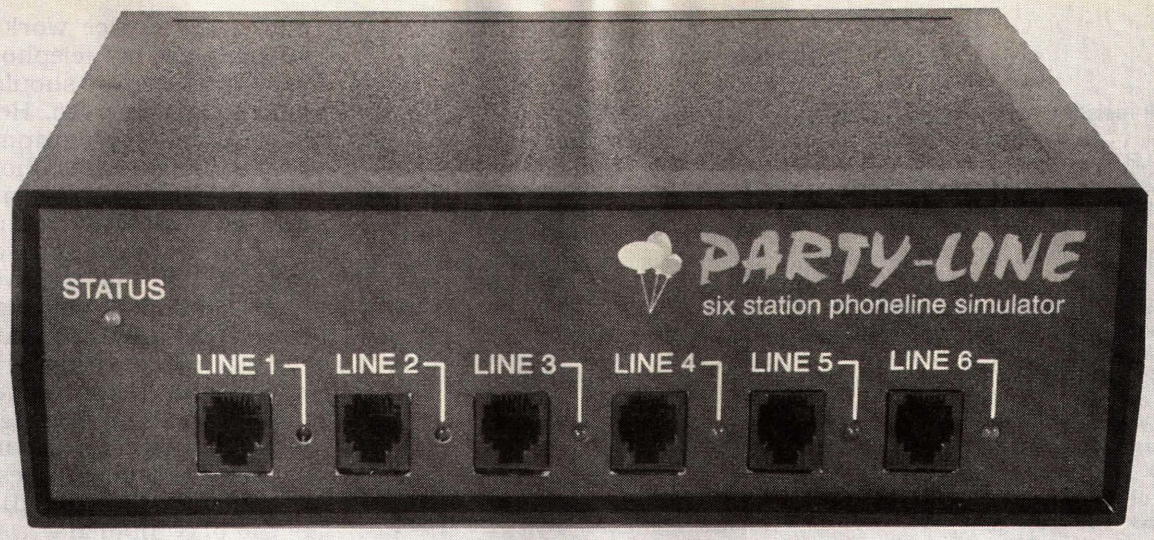
Some LEDs will light in three colors. Tri-color LEDs have two LED dies in one package (generally one red and one green) which are controlled independently. By applying a voltage greater than about 2 volts to the separate pins, the LED can glow red, green, or yellow (when both dies are on). Figure 4 is a tri-color LED circuit. With a low input level, LED2 is off. As the input voltage increases, LED2 turns on and first glows green, then yellow, and finally red.

Resistor R10 and 2.5-volt precision voltage reference IC4 provide a precision voltage reference that is further subdivided by resistors R11, R12, R13, and R14. This chain of resistors creates three different reference voltages that set the voltage thresholds for the three LED

continued on page 148

TABLE 1—COMPARATOR OUTPUT STATES

Inverting Input (–)	Noninverting Input (+)	Output
3 Volts	1 Volt	Ground
1	3	Float



BUILD THE PARTY LINE

Build the ultimate telephone-line simulator

THOMAS E. BLACK

"HEY FRED, CALL ME RIGHT BACK. I'm having trouble with my new telephone gizmo, and I need some test calls." Have you ever found yourself begging friends to call so you could test a new piece of phone gear? Given the number of telephone gadgets we all use these days, it would be great if there was a phone-line simulator that could provide authentic dial tone, ring, and busy signals. Even better would be support for features like Caller ID and Distinctive Ringing. Maybe it could be used as the hub of an in-house intercom as well. Oh yeah—it has to be inexpensive too; who wants to spend $500–800 for a commercial line simulator?

Party Line is the answer. It's probably the most sophisticated line simulator in its class, and it can be built for less than half the cost of typical low-end commercial units. Of course, some of the savings are due to a little sweat equity, so get your soldering iron ready!

Party Line supports all standard telephone-system features. You can ring up telephones, fax machines, modems, and answering machines. Just about anything that you can connect to a standard phone-line can be used with this handy device.

Party Line has a feature list as long as your arm; just describing all of its capabilities will take most of our space this month. Next time we'll continue with theory of operation and construction details. But if you're impatient to get started, we are printing the Parts List and Ordering Information this month. Complete and partial parts kits are available; we'll also publish patterns for the dual-sided PC board.

The heart of Party Line is a single-chip microcontroller. Object code for the microcontroller unit (MCU) is available from both the Gernsback BBS (516-293-2283) as file pl6.zip and the author.

Overview

Party Line offers six different telephone extensions (stations); you can freely call from one to another using several dialing methods. Only one call can be active at a time, but any number of stations can participate (hence the name Party Line). Party Line does not support rotary dialing; all calls must be made using DTMF (dual-tone-multifrequency) tones. Party Line offers life-like dial, busy, and reorder tones. Also, the microcontroller generates an accurate 20-Hz ring tone to ensure reliable device activation.

Party Line also provides four different ring patterns, which provide compatibility with the Distinctive Ringing service now offered by some phone companies. In addition, Party Line can send Caller-ID signals, a feature normally offered only by expensive line simulators. The Caller-ID information may optionally include the latest delivery format, which transmits, along with the standard date, time, and number, the caller's name! Furthermore, Party Line generates standard call-progress tones (dial tone, busy signal, ringing, etc.), so you can use the device to demonstrate and test telephone equipment. In fact, with Party Line, it's almost impossible to tell that you aren't using a real phone system.

PARTS LIST

All resistors are ¼-watt, 5%, unless otherwise noted.

R1,R39,R40,R43,R46—1000 ohms
R2,R4,R6,R8,R10,R16—220 ohms
R3,R5,R7,R9,R17,R21,R48—330 ohms
R11,R12—220 ohms, 2W, 5%, metal oxide
R13–R15,R18–R20—220 ohms, ½W
R22,R35,R37,R50–R52—10,000 ohms
R23,R24,R41—47,000 ohms
R25–R34,R36,R47,R54,R55—100,000 ohms
R38—22,000 ohms
R42,R44—100 ohms
R45—2.2 ohms
R49—470 ohms
R53—300,000 ohms

Capacitors

C1—0.47uF, 200V, metalized polyester
C2–C4,C6,C8,C15–C17,C25–C27—0.1uF, 50V, monolithic, radial
C5,C19,C20—0.47uF, 50V, electrolytic, radial
C7—0.001uF, 50V, polyester, radial
C9,C24—470uF, 50V, electrolytic, radial
C10—2200uF, 16V, electrolytic, radial
C11,C18,C22,C23—10uF, 16V, electrolytic, radial
C12–C14,C28—27pF, 100V, COG ceramic
C21—1000uF, 25V, electrolytic, radial

Semiconductors

D1–D7—1N914 signal diode
D8–D13—1N4002 rectifier, 1A, 100V
BR1—50V, 1A, W005 or equiv.
LED1–LED7—Green LED, 3mm
Q1—TIP110 NPN Darlington transistor
Q2—TIP115 PNP Darlington transistor
Q3—PN2222A NPN transistor
IC1–IC6,IC13—Optoisolator, NEC PS2501-1 or equiv.
IC7—74HC259 or 74HCT259 addressable latch
IC8—ULN2003 Darlington array
IC9,IC11—74HC14 or 74HCT14 hex inverter
IC10—PIC16C57-XT/P 8-bit Microcontroller, Microchip Tech.
IC12—LM358N dual low-power op-amp
IC14—M-991 Call progress tone generator, Teltone Corp.
IC15—M-8870 DTMF decoder, Teltone Corp.
IC16—LM317T adjustable regulator
IC17—LM7812 or LM78M12, 12V regulator
IC18—LM7805 or LM78M05, 5V regulator

Other components

F1—0.5A, 5 × 20mm fuse
J1–J6—Modular RJ11, 6/2 or 6/4 receptacle, PCB Mount
J7—1 × 3, 0.1-inch female header with shorting blocks
JU1-JU4—4 × 2, 0.1-inch pin header
P1—1 × 3 0.1-inch pin header
XTAL1—3.5795 MHz, HC18
RY1–RY6—DPDT, 12V, DC, 16–20mA coil, DIP package (OMRON G6A-234P-ST15-US-DC12 or equiv.)
T1—Transformer, split bobbin, dual 115-VAC to dual 6.3-VAC, 2.5VA (Prem SPW401D, Magnetek/Triad FS12-200, or equiv.)
T2—Telephone coupling transformer, 600:600 (PREM SPT130, Mouser TL016, or equiv.)
T3—Power transformer, 28VAC center tapped, 300mA

Miscellaneous

IC sockets, 4/40 hardware, TO-220 heatsinks (2 each for IC17 & IC18), AC power cord, 2.5-inch H × 8-inch W × 6-inch L plastic enclosure, PC board, IC sockets, solder, wire, etc.

ORDERING INFORMATION

The following items are available from Digital Products Company, 134 Windstar Circle, Folsom, CA 95630, Voice: (916) 985-7219 Fax: (916) 985-8460. E-mail: DigProd@aol.com
KITS: Parts kit including printed-circuit board, programmed microcontroller, relays, transformers, IC's, resistors, capacitors, documentation, etc., less enclosure: ($199.95). Enclosure kit includes plastic case, drilled front panel, mounting screws, etc. ($32.95). Hard-to-obtain IC's, including M-8870, M-991, ULN2003, 74HC14 (2), 74HC259, PS2501-1 (7): ($31.25). Line transformers (T1, T2) and relays (RY1–RY6): ($48.50), power transformer kit with T3 (120VAC only), fuse, AC cord: ($14.75).
PARTS: Printed Circuit Board #PL6-001: ($34.95). Programmed PIC16C57 ($22.00). Complete documentation with schematic: ($7.25).
U.S. orders add $8 S/H for Kits, or $5 for Parts. Canadian orders add $14 for Kits, $9.50 for Parts. Write or fax for shipping information to other countries.
Prices shown in USA dollars. Remit U.S. funds only. CA residents add local sales tax. Money orders, checks, MasterCard, Visa, American Express, and Discover Card accepted. Personal and company checks require bank clearance before shipment and may delay orders 2–3 weeks. Prices and terms subject to change without notice.

Party Line is compatible with most standard telephone devices, including answering machines, voice mail systems, fax machines, modems, dialers, Caller-ID displays, etc. Normally, if a device works on a POTS (plain old telephone service) line, then it should work with Party Line too. However, some telephone equipment is very particular to telephone-line characteristics, and hence may not work reliably with Party Line. For example, some devices require high talk-path voltages (>28 Volts DC), high line current (>25 mA), or true sinusoidal ring waveforms. Incompatibilities are rare because most vendors use intelligent designs that tolerate varying line signals. If a problem does occur, we suggest trying a different brand of equipment.

One unique Party Line application is as a personal intercom system. Just plug in some inexpensive telephones (or use the second line on some two-line phones), and outfit every room in your home or small office with a direct-dial intercom. You could even add a Caller-ID display to see which extension is calling!

Now let's detail Party Line features: station-to-station and quick dialing; calling all stations; dial-tone silence and recall; Caller-ID identification, blocking, out-of-area, and corrupt checksum; and distinctive ringing.

Station to station dialing

Any station can call any other. If you dial an idle station, it will ring. However, if it is in use, you will hear an authentic busy signal. If you fail to finish dialing the full station number, then a reorder tone (fast busy) will be heard about twenty seconds after entering the last digit.

To maintain realism, both local (seven-digit) and long-distance (eleven-digit) formats may be used. The long-distance number must be preceded by a 0 or a 1.

The six stations are numbered 1–6, but each responds to ten different extensions. For example, Station 1 responds to extensions 10–19. Extension numbers are always two digits long, and must be positioned as the last two digits of the phone number. The extension num-

continued on page 128

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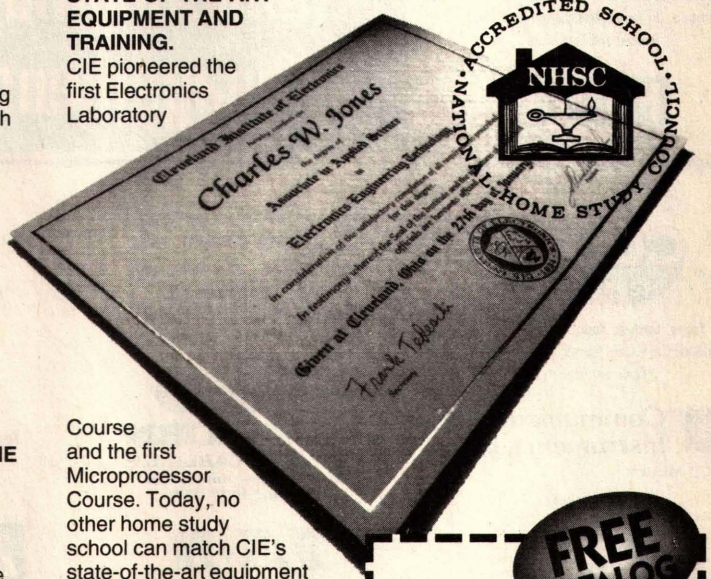

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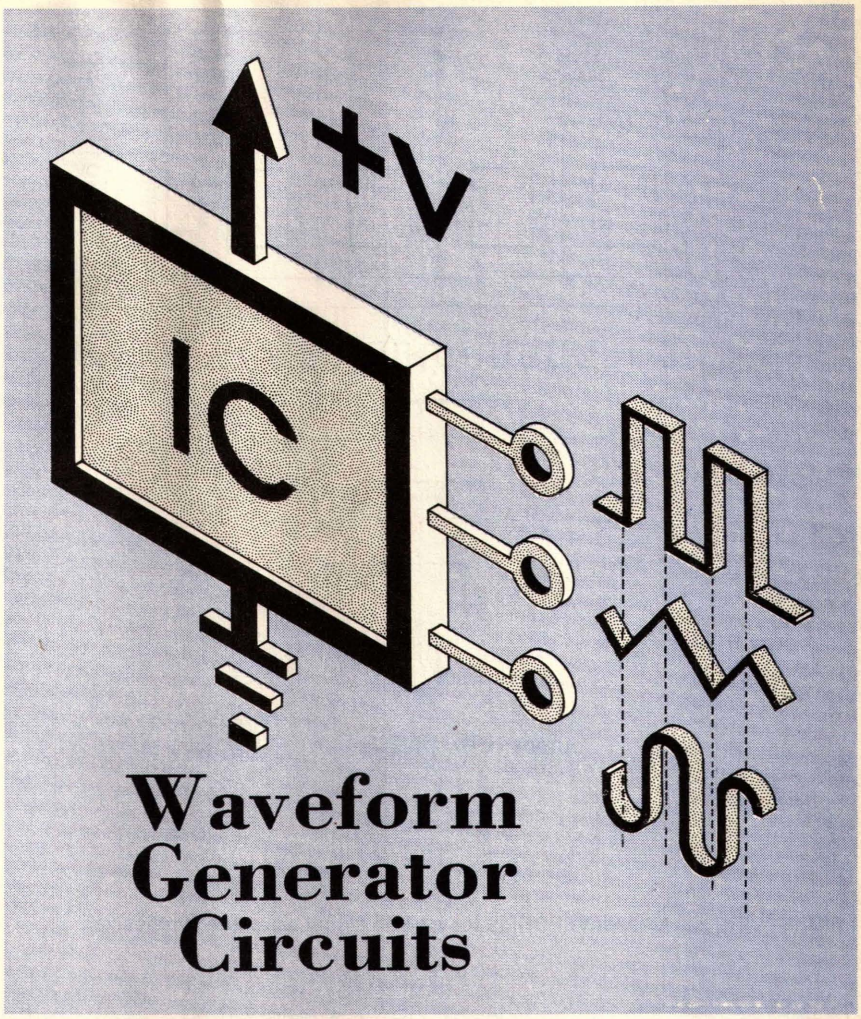

Waveform Generator Circuits

Learn about waveform generation with synthesizers, integrated-circuit function generators, and LC oscillators, and apply that knowledge to your projects.

SINEWAVES CAN BE PRODUCED BY synthesizing them from either digital or analog waveforms. This second article on sinewave generation is about sinewave synthesizers, function generators, and inductance capacitance (LC) oscillator circuits. It picks up from last month's article about resistance-capacitance (RC) sinewave generators that focused on Wien-bridge and twin-T oscillators.

Sinewave synthesizers

Figure 1 is a block diagram of a 1-kHz digital sinewave synthesizer comprised of five D-type flip-flop circuits in a Johnson counter. It is accompanied by the waveforms that would be obtained at four different locations, A, B, C, and D. The figure illustrates how a sinewave can be generated digitally by refining a coarse sinewave in a series of digital steps and then filtering out all of the digital signal's high-frequency components.

In this example, a clock signal is fed to the input of a five-stage Johnson counter. Four of the counter outputs are added together with a resistor network to produce a coarse sinewave which is then converted into a reasonably pure waverform by low-pass filter capacitor C1.

The sinewave output frequency of this circuit is one-tenth of its input clock frequency. To understand this circuit, recall that digital signals generate only odd harmonics. Thus, the harmonics that must be eliminated to obtain a reasonable sinewave are the ninth, eleventh, nineteenth, twenty-first and higher. These are easily filtered out by capacitor C1.

Figure 2 is a simple, low-cost, 1-kHz digital sinewave synthesizer based on a CD4018B CMOS presettable divide-by-N counter. This CMOS monolithic integrated circuit, designated IC1, was developed by RCA but is now produced by Harris Semiconductor and other alternate sources. The sinewave synthesizer also contains Q1, a 2N3904 NPN transistor, that converts an external 10-kHz input signal which is compatible with the signal on CLOCK pin 14.

The lowest significant harmonic of this circuit's 1-kHz output is the ninth harmonic, at −36 dB relative to the fundamental frequency. (This sinewave has about 2 % distortion.) If capacitor C1 is replaced by a second-order low-pass filter, all harmonics are attenuated 65 dB with respect to the fundamental, resulting in high-quality sinewaves with about 0.1 % distortion.

Sinewaves can also be synthesized from linear triangular waveforms. Integrated circuits, available from many sources, will perform this function. One example is the ICL8038, a precision waveform generator made by Harris Semiconductor and alternate-sourced by four other manufacturers. Another example is the XR-2206, made by Exar Corporation and alternate-sourced by at least three other manufacturers.

The Harris ICL8038

The ICL8038 waveform generator can produce accurate sine, square, triangular, sawtooth, and pulse waveforms with a minimum of external components. The frequency or repeti-

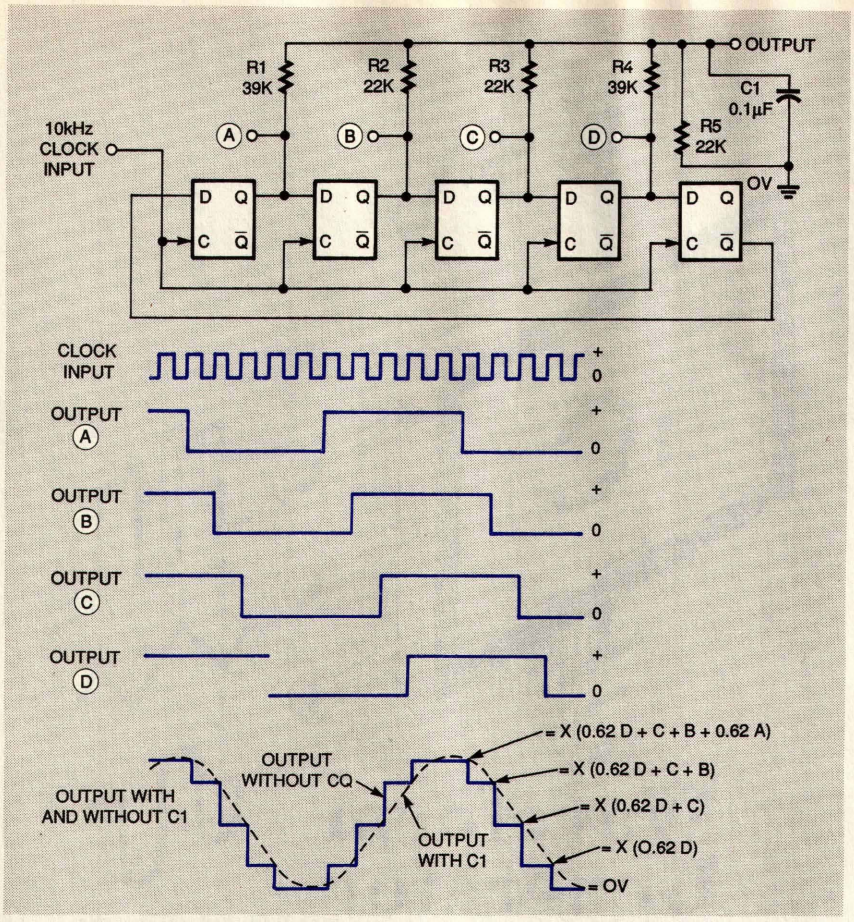

FIG. 1—CIRCUIT AND WAVEFORMS for a 1-kHz digital sinewave synthesizer.

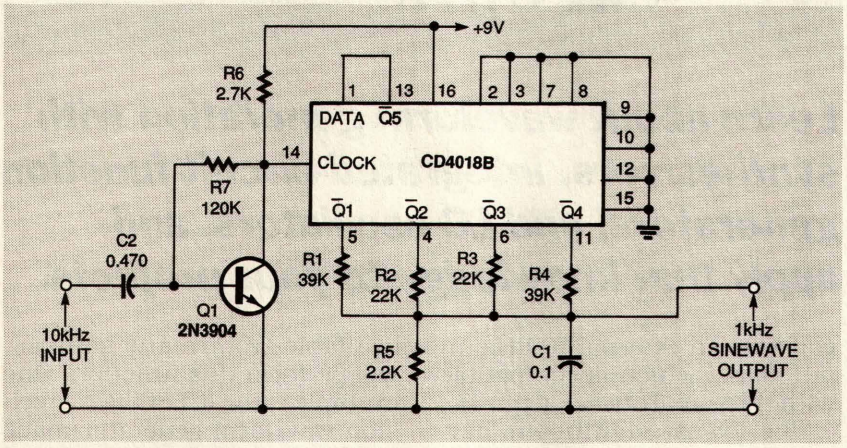

FIG. 2—A 1-kHz DIGITAL SINEWAVE synthesizer circuit.

tion rate can be selected externally from 0.001 Hz to more than 300 kHz with either resistors or capacitors. An external voltage will permit frequency modulation and circuir sweeping.

Figure 3 is the functional block diagram for the ICL8038. It contains two current sources (No.1 and No. 2), two comparator circuits (No. 1 and No. 2), and a flip-flop. Square waves are obtained from a buffer fed by the flip-flop, and a second buffer is connected on the input sides of the parallel comparators to provide triangle waves. Sinewaves are obtained by passing the triangular waves through a sine converter.

Figure 4 is the pin configuration diagram for the ICL8038. It can be powered either from a single power supply (10 to 30 volts) or a dual power supply (±5 to ±15 volts). The device provides sinewaves with only 1 % distortion and trianglular waves with 0.1 % linearity.

Figure 5 is a schematic showing the ICL8038 configured as a sine/square/rectangle-wave generator powered from a single supply. Notice that in this diagram, the FM BIAS pin 7 is short-circuited directly to the FM SWEEP INPUT pin 8. With this configuration, the values of capacitor C1 and resistors R_A and R_B determine operating frequency. The resistors set the operating values of the two internal current sources that alternately charge and discharge external capacitor C1.

Refer again to the functional diagram Fig. 3. Current source No. 2 is switched on and off by a flip-flop, while current source No. 1 remains on continuously. Without going into detail on circuit function, the important point here is that external capacitor C1 charges at a rate set by R_A until its voltage reaches two-thirds of the supply voltage. At that time, the flip-flop is triggered and changes state. External capacitor C1 is discharged linearly at a rate set by R_B until its voltage falls to one-third of the supply voltage. The flip flop is then triggered to change state again and the whole process repeats again.

Resistors R_A and R_B can have values between 1 kilohm and 1 megohm. If these values are equal, the generator circuit runs at a frequency of 0.3/RC. It generates a symmetrical linear triangular waveform with a peak-to-peak amplitude of 0.33 times the supply voltage on TRIANGLE OUTPUT output pin 3, and a squarewave with a peak-to-peak value of the supply voltage on SQUAREWAVE OUTPUT pin 9, which is loaded by load resistor R_L.

The triangle wave is fed to the IC's internal sine converter which produces a good sinewave output. Those sinewaves will have a peak amplitude of 0.22 × supply voltage at SINEWAVE OUTPUT pin 2 in Fig. 5

continued from page 130

BY DON LANCASTER

Lamps and lighting efficiency

Plus a new RGB-to-NTSC converter, ultrafast computers, and product development concepts.

I JUST GOT A HELPLINE CALL FROM AN "INVENTOR" TRYING TO "PROTECT" A "NEW" AUTO HEADLIGHT IDEA. TO STOP "DETROIT" FROM STEALING IT. I'VE *NEVER* HEARD OF "DETROIT" PAYING *ANY* OUTSIDER FOR AN untested, undeveloped, or unproved idea. Instead, "Detroit" buys parts from suppliers, and bolts them together to make cars. Automobile manufacturers are in the process of outsourcing much of their product engineering. They are significantly *reducing* their number of suppliers, and holding them to the tightest of razor thin margins.

That's strike one.

Illumination engineering is one of the few things that Fortune 500 companies happen to do very well because it requires a multi-skill project team, combined with ray tracing computers, arcane production engineering, and outstanding access to the world's research base. So, those big boys clearly have an unbeatable home-turf advantage here.

That's strike two.

The most important requirement for any headlight advance is *efficiency*. It is becoming more important because of downsizing in general and electric or hybrid cars in particular. Anything less than 100 lumens per watt won't hack it. You can bet that tomorrow's headlights will *not* be based on a heated filament.

I got the impression the caller was not a member of the SAE or the IESNA. Nor did he seem to be familiar with the relevant trade journals or to use online sources for research. He seemed to feel that car headlamp efficiency was "not important," and he apparently didn't have the slightest idea about how woefully inefficient his new design was.

That's a swing and a miss for strike three.

A realistic alternative

Let's assume that you feel that you do have a great "new" headlamp design. What can you do that works out in the real world? Step one is to immerse yourself in relevant trade publications, industry associations, and online information sources so you can make sure that you weren't talking about a product that's been sold for

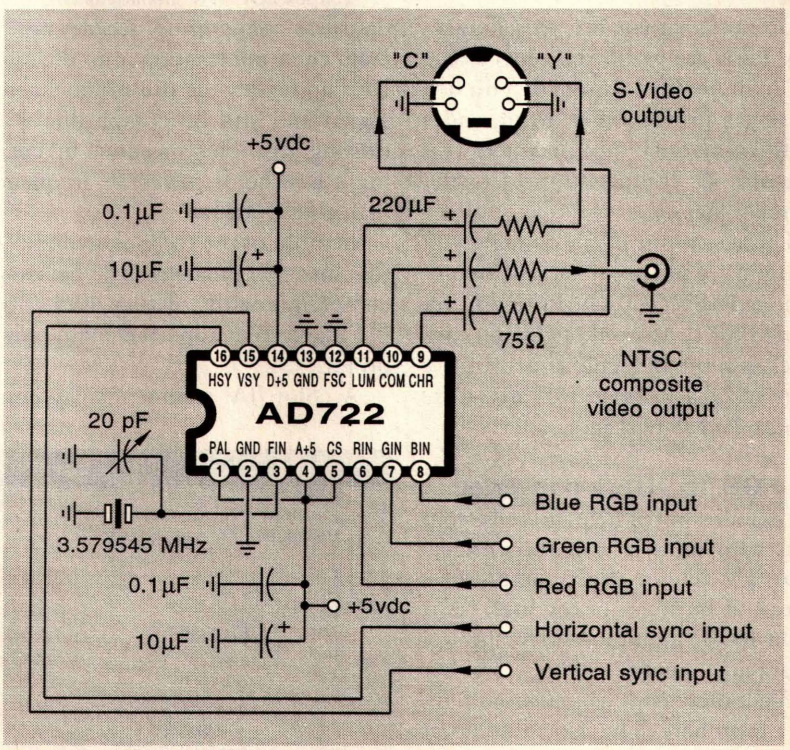

FIG 1—A NEW $8 RGB-TO-NTSC CONVERTER CIRCUIT. Note that the input sweep rates, interlace, overscan, and program content most be TV-compatible if you want useful results.

decades—or one that long ago fell off the shelf because of inherent problems.

Step two is to ask yourself , "Who likes bright headlights, and have their own wallets in their own back pockets?

Well, out here on my sand dune, the answer is glaringly obvious: four-wheel-drive desert off-roaders. To these folks, a map light is 50,000 candlepower, and a "running" light can vaporize troublesome boulders at 75 paces—on low beam.

So, first, you would have a few four-wheelers critique your design. If it is any good, you then let the local 4WD club beta test it. Once you have your tested and proven product well received, you sell a few at regional meets. Then you promote it in all the offroad magazines.

Next you seek out one or more of those off road lighting outfits. *K.C. Manufacturing* is but one of the name brand biggies out there. Competitors include *Dick Cepek*, *Hella*, *Explorer*, and *Piaa* corp. But be sure to remember the key insider secret rule for *all* successful new product development: *They must come to you*. And *never* vice versa.

Do note that you are *not* selling an idea. Ideas are worth ten cents a bale in ten-bale lots. Instead, you are offering a proven, in-demand, and a ready-to-manufacture product. You have already completed most of the high risk steps.

There is more of my thoughts on becoming a purveyor of risk reduction in RISKDOWN.PDF on my *GEnie* PSRT. More thoughts on idea development in general are in my *Blatant Opportunist* and my *Case Against Patents* packages.

An RGB to NTSC converter

I get all sorts of helpline calls from folks who want to use an ordinary color TV set for their computer—instead of buying a pricey high resolution RGB monitor—preferably via the antenna input.

Well, these days, you just can't get there from here. The TV's resolution is too low and the computer screen information content is way too high. Why do you suppose computers are equipped with all of those fancy high-resolution monitors in the first place?

No matter what you do, there is *no way* you that can display "ordinary" modern computer color spreadsheet or word processor output by RF entry on an unmodified television! All you will get is a hopelessly smeared and violently flickering illegible mess.

On the other hand, if you design your computer screen *content* to be consistent with what your TV set can reasonably and intelligently handle, then you certainly can display it. At least after format conversion. Thus, computers can be used for video titling, for *large* screen data or text, for video editing, for "slide show" presentations, or for abstract art effects.

Analog Devices has developed a greatly improved and easy to use AD722 single-chip RGB-to-NTSC encoder. I've shown a typical circuit in Fig. 1. You can use this IC to convert *already TV viewable* RGB computer output into signals a TV set can understand. But you *can not* use this (or any other scheme I know of) to let a TV replace a high-resolution monitor.

The NTSC TV broadcasting standard was conjured up decades ago to cram color information in to the same RF bandwidth as the monochrome signal and still be compatible with existing sets. This was done by creating a new color *subcarrier* frequency of 3.579545 MHz.

Because of the technology limits at the time, and the need to be backward compatible with existing TVs , the NTSC system required many compromises.

A color TV cannot display com-

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puter data because (A) its horizontal and vertical sync rates, are far too low, (B) it has a severely limited resolution that prevents more than a few dozen color changes on any screen line, (C) its interlaced display causes flicker that makes small characters unreadable, and (D) its overscan hides some of the display.

If you are able to resolve *all* of the problems mentioned, then building an RGB to NTSC converter makes sense. Otherwise, it does not.

Briefly reviewing, video on an RGB system is on separate red, blue and green lines. An extra line or two when adjacent lines are fairly similar. Since this is *never* the case with small dot matrix characters, small text will flicker badly.

The NTSC signal is purposely overscanned, gruesomely so on older sets. The reason is that if the pictured is wrapped around the side of the tube, there will be no possibility of seeing black stripes on the side. Thus *all* NTSC programming *must* guarantee that the useful stuff always ends up *only* in the *center*.

The chip is easy to use. You first apply the usual +5 volts at 30 milliamperes. Also connect pin one to

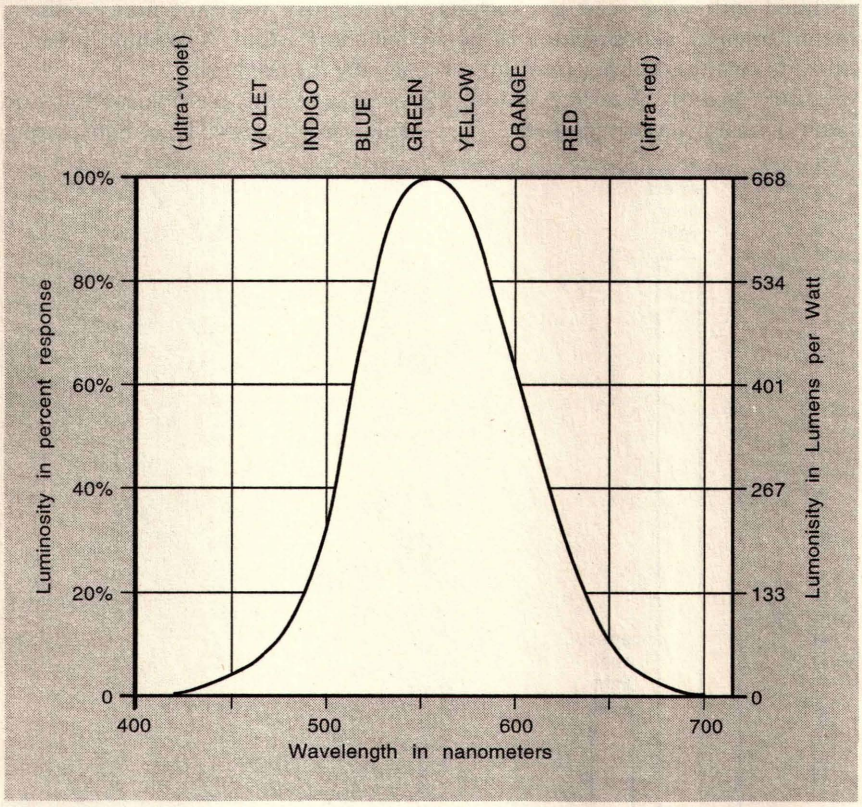

FIG 2—THE LUMINOSITY RESPONSE of the human eye varies with color. It is highest for yellow-green light, and lower for red and blue. White light sources are inherently less efficient than lime green ones.

is output for sync. Or else the sync gets combined onto your green channel. RGB scan rates are typically far higher than any TV can accept.

NTSC instead combines all of the picture information into a baseband black and white *luminance* signal and a color *chrominance* subcarrier.

The NTSC specification requires a pair of interlaced 262-$^1/_2$ line *fields* at a vertical sync rate of 59.96 Hertz. The horizontal scan rate is 15,735 Hertz. Interlace reduces flicker *only* +5 to select NTSC instead of the PAL operation. The RGB outputs of your computer can be fed directly to the red, green, and blue inputs. Three outputs are provided: the composite video, a Y luminance output, and a C chrominance output. These latter two outputs can optionally get routed to an S-video connector.

In addition, you have to get sync and the stable color subcarrier from somewhere. You can input horizontal and vertical sync on separate pins. Or else put composite sync into pin 16 while making pin 15 positive.

If you have a 4× color subcarrier clock available, input it to pin 3. If not, you can hang a stock *parallel resonant* color burst crystal from pin 3 to ground. Note that resynchronizing to a local crystal may degrade your results.

A logic high on pin 12 selects the 43 subcarrier mode, a low picks the 13 mode.

Be sure to read the data sheet carefully. There are several nasty "gotchas" to getting this chip to interact with VGA and other standards.

Conventional TV receivers require a chroma *delay line* to compensate for color shifts; a circuit equivalent to a delay line is *included* on chip so the results end up nearly identical to a broadcast signal.

The outputs are all at *twice* normal amplitude, letting you directly drive a 75-ohm reverse-terminated load.

Most VGA sources have provision for control by software. Once again, your sync rates and picture content *must* be NTSC-compatible ahead of time, or you'll get useless results.

Lighting Fundamentals

If you pick up any plain old 60 watt light bulb, it is likely to be rated around 850 *lumens*. That sounds like a bunch, until you find out what a lumen *really* is. Then you discover how badly you've been ripped off.

Well, a *lumen* is a measure of the *total output light power*. How many watts of light you will get back after gathering together all the output from all directions. (Well, usually, anyway. Some narrow-beam spotlights cheat and are rated in "effective lumens" instead.)

Being a unit of power, there is a relationship between the output light *lumens* and input electrical *watts*. This relationship also depends on the eye's sensitivity to colors. The eye responds with the *luminosity curve* shown in figure two. Eye sensitivity is highest in the yellow-green range.

A lumen is defined as 0.001496 watts of yellow-green light. Or 668.5 lumens per watt. A 100% efficient 60 watt yellow-green light bulb can thus produce 40,110 lumens.

Which means your plain old light bulb has a yellow-green efficiency of a mere 2.1%! When the other colors are considered, the total barely gets up to seven percent or so. A rating of *fourteen* lumens per watt, which is a result of nearly all the input energy being converted into useless heat.

One solution to efficiency improvement is to operate the lamp hotter. That works, but it also dramatically reduces lamp life. One workaround is the *halogen cycle*, once known as the "quartz-iodine" approach.

The result is still an incandescent lamp, but the "quartz" part means that the bulb temperature can be higher, and the "iodine" vapor part sets up a magic cycle that combines with any tungsten that is boiled off of the filament during hot times, forming a tungsten-iodide gas that is stable only when hot. The gas redeposits the tungsten right back onto the filament when it cools.

The result is a modest improvement in efficiency—Around 15% better for a 52- watt Halogen replacement lamp. The higher initial costs will eat into your energy savings, but the bulbs do last twice as long.

The larger Halogen lamps can produce up to 22 lumens per watt. Two big "gotchas" here: You must *never* touch a halogen bulb with your fingers. The oil from your skin causes a cold spot which can shatter the glass. And the lamps must *not* be continuously turned on and off. The halogen cycle only operates properly when the lamp remains on for hours at a time, with lots of cooling time between uses.

Improving efficiency

Actually, the correct term here is *efficacy*, since the output energy is in a different form from the input. There are many lamp technologies far more efficient than any incandescent. Figure three shows how all these alternates compare.

Light emitting diodes— Many new LEDs are actually *more* efficient than incandescent bulbs, and they last a lot longer, too. Cavers have long ago picked up on all of those orange superbright *Hewlett-Packard* diodes as backup light sources. The automotive industry is very excited about LED tail lights, both because of their longer life and their "instant on" feature. The latter translates to some *twenty feet* of extra safety margin at thruway speeds.

There is no fundamental physical limit restricting LED efficiency. It is more economics, material science, visual coupling, total output, and a poor performance in the blue region of the spectrum that is holding things up.

Neon lamps— These are just a pair of electrodes in a glass enclosure that is filled with some inert gas such as neon (orange), xenon (blue), carbon dioxide (white), helium (purple), or mercury (green). A current causes a glow discharge and output light.

Neon lamps are potentially very efficient "cold light" sources. The lumens per watt depends on the color. Output power is normally low. High voltages are always required. More information on these is available in *Neon News*, POP *Design*, *Sign Craft* or *Sign Business* trade magazines.

Electroluminescent panels— These are another "cold light" source. Basically, an electroluminescent panel is a capacitor with a phosphor on one electrode. A high AC voltage (100-400 volts) is applied, and its field strength excites the phosphor. The panels can produce many colors, including white. A medium green is usually the brightest.

Best results are obtained at mid audio frequencies. Total light output

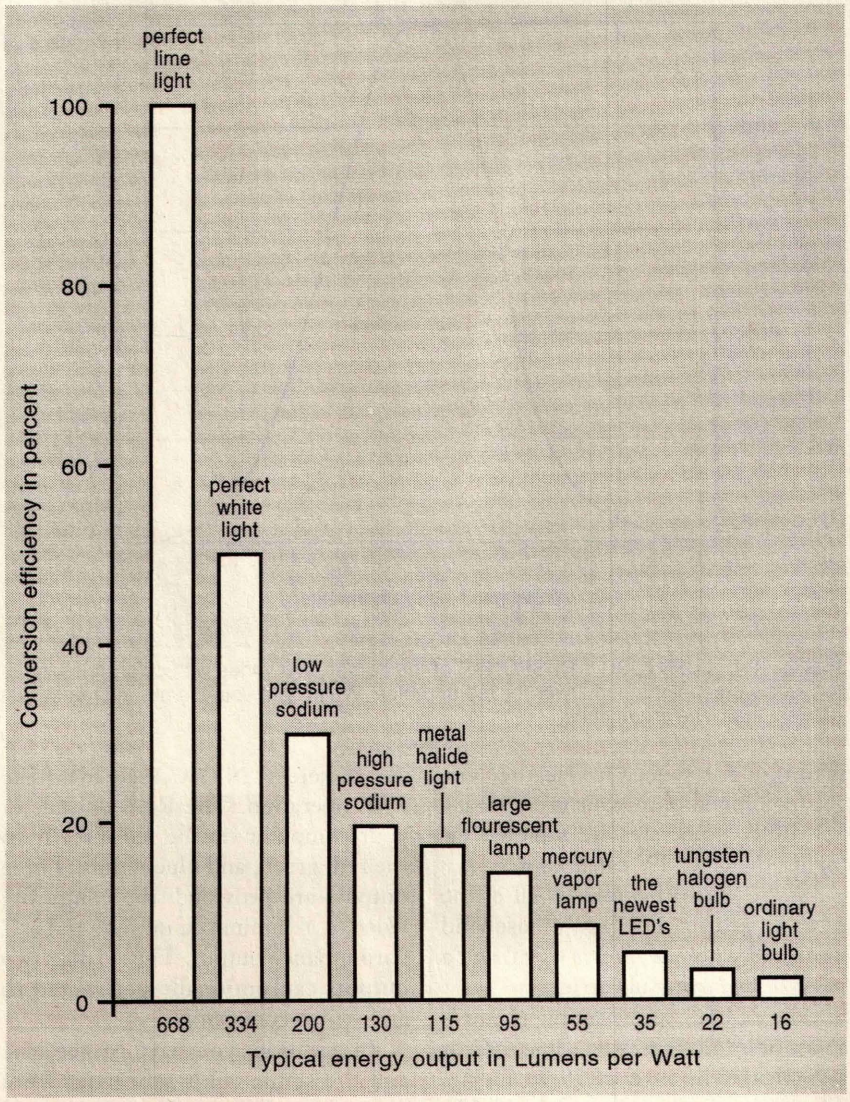

FIG 3—EFFICIENCY RATINGS for several emerging lamp technologies. Note that ordinary incandescent light bulbs are utterly awful.

is low, and the power factor makes for big time drive problems. The panel brightness drops significantly with time and contamination. Not much seems to be happening lately in new developments here. *Loctite Luminescent* is one source of information and parts.

Fluorescents— A fluorescent lamp has a much better efficiency than any incandescent, up to 100 lumens per watt. A fluorescent lamp works in two stages. First an ionized plasma discharge generates strong and narrow band ultraviolet light. That invisible ultraviolet light then impinges on a *phosphor* which downconverts most energy radiation into the visible range.

Because fluorescent lamps are current operated, a regulator in the form of a magnetic or electronic *ballast* is required. Electronic ballasts do offer *electrical* efficiencies of 85 percent and higher. They also can excite the phosphor at higher frequencies, which can help the bulb to produce more light and less flicker. Dimming is a brand new electronic option.

RF fluorescents— The phosphor of these new bulbs is excited directly by a radio-frequency source. While it is too early to tell, the efficiency of RF fluorescent bulbs should be high, but the costs, circuit complexity, and RF-interface problems must be overcome. Watch for overblown hype and investment scams on these.

Mercury-vapor lamps— These lamps are just a tiny blob of mercury and two electrodes. The mercury is heated somehow, either by direct arcing, or by a gas discharge. The vapor supports a current-limited arc discharge. The bulbs produce a bluish white light. The efficiency is 50 lumens per watt.

Because all these lamps produce a dangerous amount of short wave ultraviolet light, safety filters are a must. The life of mercury-vapor lamps is extremely long at 24,000 hours. Color rendition is only poor to fair. I get the impression their popularity has clearly peaked.

Arc lamps— Those old carbon arc lamps offered very high brightness. Their efficiency is not half bad at 120 lumens per watt, but the traditional designs consumed carbon rods and needed continuous adjustment. And they did not scale down well.

The *Welch-Allyn* folks have come up with a newer sealed variant called a *short-arc* lamp. This 21-watt point source device offers 75 lumens per watt and is intended for scientific and fiber optic applications. A special ballast is needed. Because it is as much as 43 more efficient than halogens, this sealed lamp seems ideal for battery powered apps, but it's pretty expensive.

Metal halide lamps— By far your most popular bulb for commercial and industrial lighting, metal halide lamps offer efficiencies as high as 125 lumens per watt and good color rendition. Bulb life can approach 20,000

LAMP AND LIGHTING RESOURCES

Advance Transformer
10275 W Higgins Road
Rosemont IL 60018
708-390-5000

BHK
1000 S Magnolia Avenue
Monrovia CA 91016
818-357-9667

Bulbman
PO Box 2918
Reno NV 89505
800-648-1163

Bulbtronics
45 Banfi Place
Farmingdale NY
516-249-2272

Carley
1502 W 228th Street
Torrance CA 90501
213-325-8474

Dick Cepek
17000 Kingsview Avenue
Carson CA 90746
800-992-3735

EPRI Journal
PO Box 10412
Palo Alto CA 94303
415-855-2000

Explorer
14100 Kingsley Drive
Gardena CA 90249
310-719-7285

Gilway Technical Lamp
800 W Cummings Park
Woburn MA 01801
617-935-4442

Grainger
2738 Fulton St
Chicago IL 60612
312-638-0536

Gray
4415 Indianapolis Blvd
E Chicago IL 46312
800-238-2244

Hella
201 Kelly Drive
Peachtree City GA 30269
800-247-5924

Hewlett-Packard
PO Box 10301
Palo Alto CA 94303
415-857-1501

Home Power
PO Box 520
Ashland OR 97520
916-475-3179

IESNA
120 Wall Street 17th Fl
New York NY 10005
212-248-5000

JKL Components
13343 Paxton St
Pacomia CA 91331
800-421-7244

KC Lites
PO Box 155
Williams AZ 86046
800-528-0950

Lighting Design & Apps
120 Wall Street 17th Fl
New York NY 10005
212-248-5000

Lighting Research Institute
120 Wall Street 19th Floor
New York NY 10005
212-248-5014

Loctite Luminescent
Etna Road
Lebanon NH
603-448-3444

Neon News
PO Box 668
Volcano HI 96785
808-967-7648

PIAA Corp
15370 SW Millikin Way
Beaverton OR 97006
800-525-7422

Real Goods
966 Mazzoni St
Ukiah CA 95482
800-762-7325

Welch Allyn
4619 Jordan Road
Skaneateles Falls NY 13153

hours. Typical sizes vary from 25 on up to 2000 watts. Special ballasts are required, as is an ultra violet safety filter. The filter is often built into the glass itself. Expect to see these move into home and vehicular lighting.

I'd guess that these would be the obvious choice for most future auto headlights—until something better comes along.

Low-pressure sodium— A clear cut efficiency winner at 200 lumens per watt, these "street lamps" offer extremely long life, low running costs, and outstanding nighttime visual acuity. Astronomers love them because they can dramatically minimize visual pollution. Sadly, their distinctive orange color gives a mesmerizingly awful color rendition. Sizes as small as 18 watts are offered.

High Pressure Sodium— Another sodium lamp variant, this one trades off extreme efficiency for a greatly improved color rendition. At low gas pressures, the emission takes place in distinct spectral lines. As pressure increases, the lines first broaden, and then become more continuous. These can offer 120 lumens per watt with no ultraviolet filter hassles.

A 10,000 hour life is common. The sizes range from 35 up to 1000 watts. The cost is around $90 in single quantities. Mercury-vapor ballasts can be used. Most operate in any position.

Lighting resources

I have gathered up a few lighting resources for you as this month's sidebar. Besides those I have already mentioned, a few deserve comment.

IESNA, which publishes *Lighting Design and Application* magazine plus a technical research journal, seems to be the main trade association. There is also a *Lighting Research Institute* in the same building.

The EPRI journal is by the *Electric Power Research Institute*, which offers fine reference materials.

The leading industrial source for lamps is *Grainger*. Graphics arts lamps are usually sold by *Bulbman*, *Bulbtronix*, *Gray*, and *HID Systems*, among many others.

Two manufacturers of the smaller lamps are *Gilway* and *Carley*. JKL is a good source for low cost miniature fluorescent lamps, while BHK offers specialized ultraviolet lamps. *Advance* is the leading ballast supplier.

Home Power is a fine magazine for off-grid lighting applications. A high-profile lamp and alternate-energy supplier is *Real Goods Trading*.

Please let me know if I missed any of your favorite sources here. A free *Incredible Secret Money Machine II* for your trouble.

A great read

I was impressed by *The Shoulders of Giants*, a history of early aviation. Written by Phil Scott and published by *Helix Books*.

There was a government aviation fiasco at the time of Kitty Hawk that cost hundreds of times more than the Wright Brothers' success. This program only succeeded in filling the Potomac River with broken bits and pieces of planes and pilots.

The Wright Brother's patent fights clearly set US aviation back far more than their early flights ever advanced it. For decades, even.

The initial transcontinental flight crashed so many times that only an original wing spar and most of the pilot actually ended up on the west coast. And, of course, the Red Baron failed his flight test three times.

continued on page 50

NAMES AND NUMBERS

Analog Devices
PO Box 9106
Norwood MA 02062
617-329-4700

Atmel
2125 O'Nel Drive
San Jose CA 95131
408-441-0311

Flexible Circuits
6195 Corte del Cedro #110
Carlsbad CA 92009
619-431-2869

Focal Press
313 Washington Street
Newton MA 02158
617-928-2500

GEnie
401 N Washington St
Rockville MD 20850
800-638-9636

Helix Books
Addison-Wesley
Reading MA 01867
617-944-3700

Image Processing Resources
PO Box 207
T or C NM 87901
800-735-3596

Intel Corporation
2200 Mission College Blvd
Santa Clara CA 95052
800-548-4725

The Mart
899 Presidential #110
Richardson TX 75081
800-864-1155

P-O-P & Sign Design
7400 Skokie Blvd
Skokie IL 60077
708-675-7400

Power Transmission Design
1100 Superior Avenue
Cleveland OH 44114
216-696-7648

Riteco Supply
12999 FM 529
Houston TX 77041
713-896-6200

Roland Users Group
7200 Dominion Circle
Los Angeles CA 90040
213-685-5141

SAE
400 Commonwealth Drive
Warrendale PA 15096
412-776-4841

Science/AAAS
1333 H St NW
Washington DC 20005
202-326-6400

Sign Business
1008 Depot Hill Office Pk
Broomfield CO 80020
303-469-0424

SignCraft
PO Box 06031
Fort Myers FL 33906
813-939-4644

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2201 Laurelwood Road
Santa Clara CA 95054
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Synergetics
Box 809
Thatcher AZ 85552
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Lake Geneva WI 53147
800-420-0579

BY JEFF HOLTZMAN

Return to reality

THE EDITORS HAVE GOTTEN ON MY CASE ABOUT THE ESOTERIC NATURE OF SOME RECENT COLUMNS. FINE: BACK TO THE WORLD OF BITS AND BYTES AND SOLDERING IRONS. TOPICS THIS MONTH include Pentium updates and hard-disk utilization.

Pentium updates

Today's CPU of choice is the Pentium. It is currently available in speeds ranging from 75 to 133 MHz, with faster units (150- and 180-MHz) on the way. If you have an old 486-based computer that you aren't quite ready to part with, Intel sells various OverDrive CPU's, as either 486 upgrades or Pentium upgrades.

At the other end of the spectrum, Intel has announced the successor to the Pentium. If you were hoping for the next logical step (Sexium), you'll be disappointed. Depending on whether you run "true" 32-bit software, you may also be disappointed with performance.

For the 486 upgrade crowd, Intel appears to have done everything possible to confuse the issue. You can follow one of several upgrade paths: a clock-multiplied 486 or a Pentium OverDrive. The clock-multiplied 486 route provides a faster CPU, and in some cases a larger cache than the original CPU (16 kilobytes vs. 8 kilobytes). The Pentium OverDrive route stuffs a ten-pound Pentium into a five-pound 486 socket.

In general, although an upgrade CPU can improve performance, in no case can it provide system-wide performance equal to that of a comparable Pentium system. Both the CPU's efficiency at transferring data and internal software optimization of the CPU guarantee that a true Pentium will run faster at a given clock rate than any of the upgrades under discussion.

Nonetheless, recently published data suggests that CPU upgrades, particularly for lower-end 486 systems, can significantly improve performance. Figure 1 summarizes data recently published by the trade weekly *PC Week*. The diamonds represent the cost of each

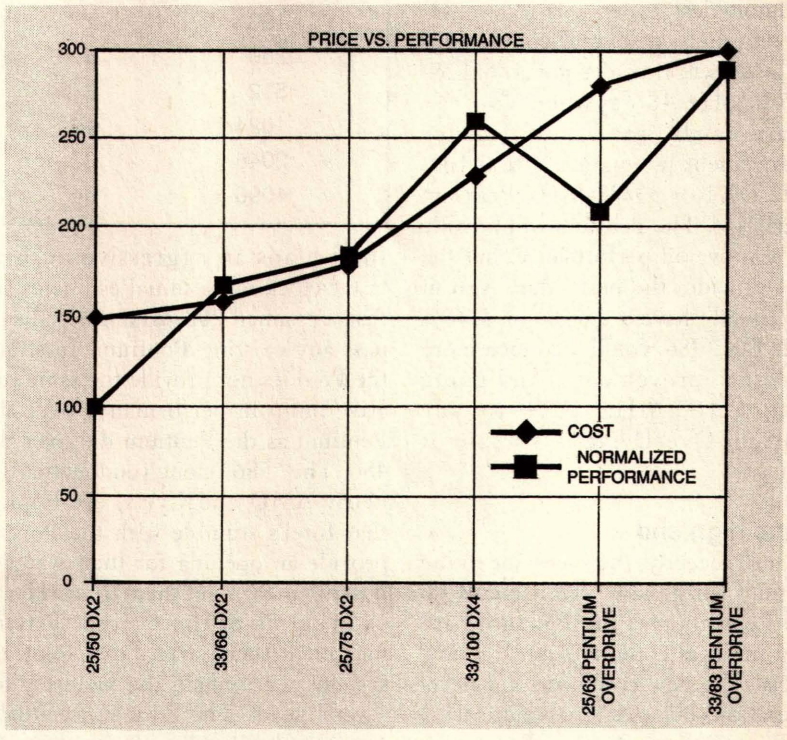


FIG. 1—THIS CHART SHOWS PERFORMANCE IMPROVEMENT percent over a base 486/25 system running application-level benchmarks. Source: PC Week, 9/18/95, p. 133.

upgrade level; the squares represent relative performance figures normalized to fit the vertical scale. Performance data is relative to a 25-MHz 486 system.

Several facts are clear. First is that the 25/63-MHz Pentium OverDrive provides poor value. Although its price is higher than its predecessor, it will actually degrade system performance.

Second, although the Pentium OverDrives generally provide better performance than DX2 and DX4 devices, the cost differential is out of line with the performance increase. For example, going from the 33/100 DX4 to the 33/83 Pentium increases cost by 23%, but increases performance only 12%.

The data presented in Fig. 1 is representative only; the original study cross-tabulated the results of upgrading from several CPU's to several others, and results are not consistent across all upgrade paths. In addition, the study unfortunately neglected to include processor upgrades from other manufacturers, including AMD, NexGen, Cyrix, Evergreen Technologies, and Kingston Technologies.

Nonetheless, several conclusions can be drawn. If you've got an old 25- or 33-MHz 486 system, you can obtain fairly good performance improvement by upgrading to a 100-MHz DX4 or 33/83-MHz Pentium OverDrive. The Pentium will provide the best overall performance, but the DX4 provides the best value. Also, if you already have a 25/50- or 33/66-MHz DX2 486, you'll see much more modest improvements. And going from a 100-MHz DX4 to any Pentium OverDrive is a waste of money.

At the high end

Until recently, the successor to the Pentium has gone by the name of P6 (the Pentium was the P5; those are Intel internal code names). It's now official: the new (I almost said next-generation, but that's not quite true) CPU is called the Pentium Pro.

In midsummer, chips and systems went out to vendors and trade publications, and in recent weeks preliminary benchmark and compatibility tests have come in. The upshot is that if you're running pure 32-bit code (Windows NT, OS/2, or some form of UNIX), the P6 will look like a true next-generation CPU. But if you're running impure 32-bit code (Windows 95 or Windows 3.1), the P6 will look more like a Pentium upgrade, and maybe not even that. In fact, after news of the P6's laggard performance hit the streets, Intel promptly gave it the new name.

According to the company, the name is intended to capitalize on the millions of dollars poured into name-brand recognition advertising. On the other hand, a cynic (I mean a realist) might suggest that it's to lower expectations concerning the P6. Is it a next-generation CPU or an enhanced Pentium? Only Intel's marketing department knows for sure.

Another point is that the current 150-MHz P6 does Windows no better than a 100-MHz Pentium. But Intel plans an aggressive push to faster clock rates; initial estimates are that a planned 200-MHz P6 will surpass any existing Pentium. In short, the P6 does not provide the same relative jump in performance over the Pentium as the Pentium did over the 486. The "586" clone vendors (particularly AMD and Cyrix) are hoping that Intel's stumble with the P6 will provide an opening for their wares—if they can ever get them to market.

TABLE 1
DISK AND CLUSTER SIZES

Disk Size (megabytes)	Cluster Size (kilobytes)
128	2
256	4
512	8
1024	16
2048	32
4096	64

In terms of the overall systems market, it seems likely that Pentium systems will remain the mainstay for several years. The P6 may eventually overtake the Pentium, but it may not. If the vast majority of users are going to be using mixed 16/32-bit environments for the next few years, there seems little incentive to move to the P6. If Windows 95 were to fall flat, and Windows NT were to take over, the P6 would probably move into prominence sooner. But despite its faults, Windows 95 seems to be catching on about as well as Microsoft could have hoped.

Wasting space

This has bothered me for years; as we move to 1-gigabyte and larger hard disks, the problem is only getting worse. The problem is clustering. A hard disk drive consists of one or more platters, each of which contains a set of concentric circles called tracks, each of which is divided into a set of segments called sectors. On a floppy disk, every sector contains 512 bytes of data. On a hard disk formatted for DOS or Windows or OS/2, a sector also contains 512 bytes.

However, because DOS has only 16 bits to keep track of which sectors are used and unused, files are not allocated in units of sectors, but in groups of sectors called clusters. A cluster contains 2K * n bytes, where n is a number from 1 to 32. Hard disks smaller than 128 megabytes have 2-kilobyte clusters; today's common 1-gigabyte drives have 16-kilobyte clusters. Table 1 correlates drive and cluster size.

What difference does it make what the cluster size is? If you have lots of large files, it won't make much difference. But if you have lots of small files, DOS will waste a lot of space. For example, assume you have ten 200-byte batch files. The space required to store them is simply $10 \times 200 = 2{,}000$ bytes. But because each file must be stored starting in a new cluster, some space must be wasted. On a small hard disk (less than 128 MB), those batch files would require $10 \times 2048 = 20{,}480$ bytes. A 1-gigabyte hard disk, would require $10 \times 16{,}384 = 163{,}840$ bytes. For this example, the efficiency of the small disk is $100 \times 2000 \div 2048 = 9.77\%$; for the large disk, it is $100 \times 2000 \div 163{,}840 = 1.22\%$. Ten percent is bad, but one percent is ridiculous!

Don't get the wrong idea; the fact that a few small files waste a fair amount of space does not mean that

overall disk utilization is that low. Most systems have a mix of large and small files; efficiency typically varies 70–90%.

How do you know what your disk's space efficiency is? You can get a rough estimate using DOS's DIR and CHKDSK commands. By running CHKDSK you can learn your disk's total size, cluster size (CHKDSK reports clusters size as "allocation unit"), and space allocated for files. By typing "DIR /S" from your root directory (and waiting patiently), you'll eventually end up with a display listing total bytes used by the files on your disk. You can then calculate your waste factor as (1 – (bytes used ÷ bytes allocated))×100%.

For example, one system on my network has a 1-gigabyte SCSI drive. CHKDSK told me that 784,515,072 bytes were allocated to files, and DIR told me that 627,110,564 bytes were actually stored in those files. Applying the formula, I come up with a waste factor of 20.1%. Twenty percent of 784.5 megabytes is 156.9 megabytes. Wasting 150 megabytes of disk space does not make me happy!

You can get a somewhat more accurate display of disk utilization, along with some other interesting statistics, from a utility, CHKDRIVE, written by *PC Magazine* columnist Jeff Prosise. Jeff's program scans your entire hard disk counting space allocated and used by the files. I'll post a copy of CHKDRIVE.ZIP on the Gernsback BBS (516-293-2283). The file includes both the executable and the C source.

References:

PC Week, 9/18/95, p. 133.
Byte, 10/95, p. 26
PC Magazine, 6/27/95, p. 249
PC Magazine, 10/10/95, p. 345


```
DIR /s output
Total files listed:
   17,579 file(s)     627,110,564 bytes
                      224,493,568 bytes free
Chkdsk output
1,050,411,008 bytes total disk space
   21,364,736 bytes in 20 hidden files
   19,382,272 bytes in 1,182 directories
  784,515,072 bytes in 14,047 user files
  224,526,336 bytes available on disk

       16,384 bytes in each allocation unit
       64,110 total allocation units on disk
       13,702 available allocation units on disk

Chkdrive output
Scanned 14,070 files in 1,183 directories on drive C:
Cumulative length of all files is 648,207,406 bytes
Cluster size is 16,384 bytes (16K)

Cluster Size    Overhang (Bytes)    Efficiency
============    ================    ==========
      2K             15,336,402        97.7%
      4K             33,211,346        95.1%
      8K             72,549,330        89.9%
     16K            157,623,250        80.4%  <--
     32K            341,156,818        65.5%
     64K            739,124,178        46.7%
```

HOW MUCH SPACE ARE YOU WASTING? calculate you drive's efficiciency and find out.

What's the solution? You can partition large drives into several smaller ones. By keeping the logical drives less than 128 megabytes, you can ensure minimum waste factor. But managing eight or ten drives can be a pain in the rear. And adding another large drive could easily exhaust available drive letters.

Another possibility is to use disk compression—either Microsoft's or a third party's—to decrease the waste factor. The reason is that disk compression programs typically pack files in byte rather than cluster boundaries. The problem is that disk compression exacts a toll in terms of performance and robustness. In addition, the MS-supplied DOS 6.x compression programs have a maximum compressed volume size of 512 megabytes, which means that you'd have to partition a 1-gigabyte drive into four chunks. The disk compression available in Windows 95 allows volume sizes up to 2 gigabytes, but even that can be a limitation.

The real solution is a better built-in file system. What about it, Microsoft? EN

LETTERS

continued from page 23

When New Tek built the toaster for the Amiga, it was a plug-in card. When it decided to build one for the PC, it had to be a stand-alone unit that could only be interfaced with the PC. The PC does not have the video capabilities or operating system to support a plug-in card. New Tek had to make a stand-alone processor and write an operating system that could handle the taxing video demands. That says volumes about the Amiga and its "stellar position.'"

KURT D. SWAIM
Fort Wayne, IN

AN INNOVATIVE HEAT GUN

I recently discovered an inexpensive but useful electronics-related tool. I was looldng into the bore of my Presto Poplite hot-air popcorn popper, and I noticed that it had no moving parts and was able to produce a very hot stream of air from its mesh-covered bore. I realized that this appliance might make a good heat gun for heat-shrinkable tubing.

I found the same model for sale in a thrift store for $2. I found I had an excellent benchtop heatgun after I removed the outer housing. The short assembly stands on three legs. I secured its wires with some wire ties and a cable clamp, making use of an existing screw. Also, the unit had some exposed terminals that I covered for safety reasons. I found that the heat comes up so fast that it will shrink the tubing as soon as it's plugged in.

PETER PINETTE
Cape Coral, FL

BY LARRY KLEIN

Cables (and interconnects) revisited

TOM NOUSAINE IS ONE OF THOSE DEDICATED AUDIOPHILES WHO HAVE THE TIME, INTEREST, AND KNOW-HOW TO SCIENTIFICALLY INVESTIGATE POTENTIAL IMPROVEMENTS IN HI-FI PERFORMANCE.

He didn't set out to be a "debunker," but his rigorous test procedures have often made hash of the mystical beliefs propagated by the high-end audio aficionados. In an article in the September issue of the excellent Canadian publication *Sound & Vision* (99 Atlantic Avenue, Suite 302, Toronto, Ontario MK6 3J8, Canada), Tom notes that nothing new has been published on controlled cable-listening tests in about 10 years. In the meantime, audiophile speaker cables have proliferated wildly, all accompanied by preposterous performance claims and outrageous prices.

Tom, who lives in an area well populated by audiophile cable aficionados, asked the members of his audio club to participate in double-blind speaker-cable listening evaluations. The test was to determine whether they could differentiate by ear the performance of their own audiophile cables against ordinary 16-gauge electrical zip-cord. In Tom's words, "The challenge had the majority of potential listeners diving for their shoelaces," but two courageous—or overconfident—listeners accepted the dare. Each audiophile's own system, listening room, and music served as his test base.

In the series of double-blind listening tests, the participants were asked to distinguish between setups incorporating such cost-wise opposites as a $900 set of cables and $15 worth of zip-cord. After a discussion of the test procedures and results, the remainder of Tom's article is an excellent tutorial on the statistical analysis and philosophy of double-blind testing.

Were the two audiophiles able to hear the difference between their own costly and highly touted esoteric cables and the ordinary zip-cord? Much to their shocked surprise they could not. To my surprise, neither one copped out by claiming that the test techniques were somehow flawed and therefore obscured the differences they heard normally under non-test conditions. I guess for some brave souls, at least, the truth will make them free—of excessively expensive cables, that is.

Tom recently conducted a new round of tests with his audio club members, this time comparing high-end "interconnects" to ordinary phono cables. The results were the same: audiophile efforts to pick out their own expensive interconnects by ear averaged out to no better than guesswork.

SALES OF MINIDISC PRODUCTS have been below expectations so far.

DCC and MD

Have you been as puzzled as everybody else by the increasing proliferation of competing and non-compatible new audio/video products? We have barely bought into one new format before other non-compatible competing formats are introduced. A brief historical review of the hi-fi industry will help explain what I think is going on.

When I first become involved, in the 1950s, each round of audio new-product introductions seemed to embody real advances. Perhaps some of the audible improvements I heard were illusory, but in any case, I found myself compulsively upgrading with, say, a new tuner

that pulled in more stations with less noise, a turntable with lower rumble, a tape recorder with a wider frequency range and lower hiss and flutter, an amplifier with more power and lower distortion, and speakers with higher highs and lower lows. Over the years, the stuff just kept getting better, we audiophiles kept upgrading, our numbers kept increasing—and the hi-fi manufacturers prospered.

Then stereo FM and records appeared. There was the expected grousing and muttering about planned obsolescence and having to buy two of everything, but after a shaky start stereo sold, mono equipment was replaced, the market continued to expand, and the manufacturers smiled all the way to the bank. Stereo equipment, like the mono components it replaced, continued to slowly improve, and consumers upgraded as they found themselves in the mood and with the cash.

Then came "space-age technology" in the form of the transistor. Manufacturers saw a wonderful opportunity to sell new electronic everythings to everybody. Unfortunately, it didn't work out that way. Impatient audiophiles unwary enough to be suckered in by the hyperbolic ads of the day found themselves with tuners that overloaded on strong stations and amplifiers that distorted badly, or blew up, blew out, or quietly died.

It took several years for the transistor manufacturers and component designers to get their acts together, but today's solid-state equipment is vastly superior to the best of the old tube equipment in reliability and longevity, and at least their equal in sound quality—despite the contrary opinions of a smallish group of die-hard tube fundamentalists.

You couldn't tell it from the new-equipment ads, but, in general, progress in standard hi-fi components came to a halt about 10 to 15 years ago. Each year's new models have come with a full complement of bells and whistles and have sounded fine, but most have performed no better than the 5- to 10-year-old units sitting on consumers' shelves.

The longevity of the equipment and its fine performance meant that the average music listener was no longer motivated to engage in regular replacement or upgrading. And besides, computers and various video goodies were competing for his discretionary dollars. True, newcomers still entered the audio marketplace, but their numbers were not sufficient to satisfy the expanded capabilities of the mass-market Japanese manufacturers. Their solution? Stop trying to kick start a dormant or too slowly expanding marketplace with new models of old products, but instead develop new product categories to tempt the customer.

Such thinking can indeed pay off, as was demonstrated by car audio equipment, the VCR, the Walkman, CD, and recently, multi-channel home-theater equipment. However, the last decade or so has seen several instances of new formats that haven't made it. Philips' digital compact disc (DCC) and Sony's MiniDisc (MD) are the two latest examples.

The trade publication *Billboard* reports that the DCC is moribund with only 8,000 units sold. And Minidisk sales are also far below expectations.

There's nothing wrong technically with either product; in fact the MD is a technological *tour de force*. The problem is that both units are designed to meet a consumer demand that never existed, except perhaps in the wish-fulfillment fantasy of some marketing maven. How much marketing research was done to gauge potential consumer interest in the MiniDisc and DCC? Perhaps Philips and Sony—and other manufacturers—would do well to put more effort into market research before committing themselves to costly product-development programs.

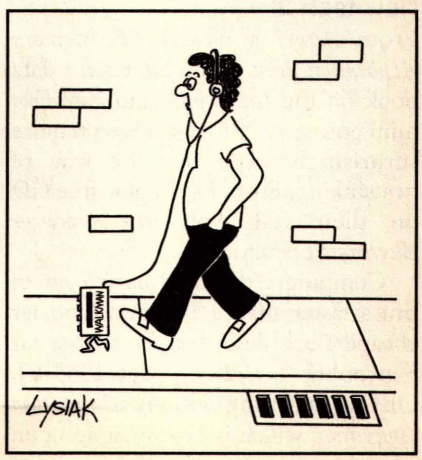
Getting OSHA out of our ears

Most of us know the Occupational Safety and Health Administration (OSHA) as the government agency that monitors workplace hazards—including potentially ear-damaging industrial noise levels. In my June 1995 column, I criticized OSHA for not being stringent enough in its noise standard, noting that other regulating bodies here and overseas have advocated levels significantly lower than OSHA's legal maximum limit of 90 dB for 8 hours.

Incidentally, OSHA does not do its own research; another related agency, the National Institute for Occupational Safety and Health (NIOSH), establishes the standards that OSHA enforces. Or at least, that's the way it used to be.

As you may have noticed, there's a new Republican majority in Congress dedicated to the proposition that government has far too much control over our lives. In their view, we are being oppressed by the agencies that set minimum standards for food contamination, drug effectiveness and safety, product safety, water, air, and land pollution, industrial safety and noise, and so forth. To alleviate this intrusion into private-enterprise competitiveness, the House of Representatives slashed the funding for NIOSH by 25 percent as down payment on the House Budget Committee's promise to phase out the agency in four years.

Because OSHA and NIOSH, along with the FDA and the EPA, are all on the Republican hit list, I may in the near future no longer have cause to complain about the inadequacy of industrial noise-protection standards and/or their lax enforcement simply because there won't be any standards to complain about! It isn't clear to me how U.S. industries will be more competitive worldwide when the U.S. workforce is sick or deaf, but that is just one more thing that I don't understand about politics in 1995. EN



WHAT'S NEWS

continued from page 4

Nevertheless, scientists at Los Alamos National Laboratory in New Mexico are testing a prototype fuel that they believe can overcome these problems and eventually power cars.

Fuel cells convert chemical energy to electrical energy without combustion. Unlike the battery in an electric car, which requires long recharging stops and has a limited driving range, a fuel cell powered vehicle could be refueled quickly. Moreover, it would have nearly the same driving range and performance as a conventional four cylinder car.

The Los Alamos team designed an power system that runs on multiple proton-exchange membrane fuel cells and is fueled by liquid methanol or wood alcohol. An on-board fuel processor converts the methanol into hydrogen and carbon dioxide. The fuel cell electrochemically combines the hydrogen with atmospheric oxygen to produce DC for powering the car's traction motors.

A 30-kilowatt fuel-cell stack is expected to have a volume of about a cubic foot. After testing it to determine its voltage output as the electrical load and fuel are varied, the fuel-cell stack will be built into a complete methanol-to-electric power system. The propulsion system will be tested over simulated driving conditions.

The overall goal of the Los Alamos, General Motors, and Department of Energy project is to develop an automotive-scale fuel cell that will more than double a car's fuel economy and reduce emissions by as much as 90%. A 10-kilowatt fuel cell was developed in the first phase of the project. The goal of the project's second phase, is the 30 to 50-kilowatts required to match the performance of gasoline-powered cars.

Methanol can be obtained from agricultural waste or from natural gas. It would have to be available at thousands of filling stations, but this is seen as less expensive than installing battery-recharging stations and power plants for battery-powered electric cars. EN

VIDEO NEWS

continued from page 6

in 2, 4, 10 and 15 megabyte capacities. A 2-megabyte card could hold 20 to 24 digital snapshots or 30 to 60 minutes of audio or 1,200 pages of double-spaced text and will be available late this year, at something under $100 to start. An idea of who is interested in flash memory is revealed by membership in the Compact Flash Association: Apple, Canon, Eastman Kodak, Hewlett-Packard, LG Semiconductor (Goldstar), Matsushita (Panasonic), Motorola, NEC, Polaroid, SanDisc (formerly SunDisc), Seagate, and Seiko Epson. The association plans to make technical specifications and the Compact Flash trademark available under royalty-free licenses to promote the standard.

More digital camcorders

Japanese camcorder manufacturers continue to introduce digital camcorders using the standard "DV" (for digital video) format. JVC's version, described as "the world's smallest camcorder" isn't much bigger than a VHS cassette box. It has a single-CCD pickup and weighs 1. I pound loaded with battery and mini-cassette. Panasonic has added a second model to its line, this one with single CCD (the first had three) and a four-inch LCD color monitor. Sharp introduced its first "Digital ViewCam" featuring a five-inch LCD monitor, three CCDs and an interface for connection to a personal computer. The two Sony models introduced previously and Panasonic's three-CCD model (*Electronics Now*, December 1995) are currently available in the U.S., and the new versions are expected here this year as well. None of them will come cheap, with prices starting above $2,000. But we're talking electronics—so if the price is too steep now, just wait. EN

HARDWARE HACKER

continued from page 44

New tech lit

From *Atmel* a new *Flash Memory Application Book*. From *Siliconix*, a data book on the *Little Foot* and *Lite Foot* mini power MOSFETs. These require surprisingly little in the way of heatsinking. From *Intel* a new free CD on their full i960 *Microprocessor Electronic Library*.

Computers that can be *billions* of times faster than a Pentium (and far cheaper) are described in *Science* for September 8, 1995 on page 1363-64. One of the many options is *quantum computing*, which is expanded upon on pages 140-145 of *Scientific American* for October of 1995.

Roland magazine is a free publication that covers synthesizers and related electronic music topics. Roland has also come up with a new *Sound Canvas*. An entire synthesizer in a single PCMCIA card.

Power Transmission Design is a new trade journal on motion systems. *The Mart* is a big-time major shopper on phone parts and systems.

Flexible Circuits Engineering is a brand new trade journal on bendable printed circuit materials.

Hoop Pine Plywood is a flexible wood suitable for model making and prototypes. Free samples are offered by *Riteco Supply*.

The free *Media Arts Catalog* from *Focal Press* stocks hundreds of titles on everything from nonlinear editing to time codes to script writing.

For high end hardware, try *Image Processing Resources*, which supplies lighting, lenses, cameras, frame grabbers, and more. Lots of great cartoons in the company's free catalog.

A *BBS Radio* directory is available from *Tiare Publications*. But do note that it lists only hobby BBSs. The outstanding Radio board up on *GEnie* is not mentioned. Nor is any other major commercial resource. Or anything on the Internet.

Reprints and preprints of most of my stories are available on my *GEnie* PSRT RoundTable. EN

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Caller Block
Connects between your telephone and its wall jack, and prevents the phone from ringing unless the calling party is one which you've entered into memory using your touch-tone phone. Your answering machine can handle all other calls. Change between two separate directories of callers with a simple flip of a switch. $46.00

Telephone Caller ID
Connects to telephone wall jack. Shows the telephone number of the calling party along with the time of day the call was received, on a 16x1 character LCD display. Stores the info from the last five calls in memory. Complete stand alone, no computer interface needed. $52.50

Telephone Call Restrictor
Connects to telephone wall jack. Disables all phones on the line if attempting to either: dial a number that has been stored in memory "Block Mode" or, dial a number that has not been stored in memory "Allow Mode". Use touch-tone phone to enter telephone numbers into memory, and choose mode. Program from any phone on the line using your password. $35.00

50 MHz Frequency Counter
Reads frequency from 1Hz to 50MHz and displays it on a 16x1 character LCD display. Auto-range feature provides floating decimal point and automatically affixes the correct suffix (Hz, KHz, or MHz). Microcontroller based, very few additional components. $46.50

Telephone Scrambler
Scrambles your voice before sending it over the telephone line, and descrambles it on the other end. Connects between your telephone and wall jack. No modifications are required to your telephone. Full duplex operation. $43.00

IR Remote Control Receiver
Learns and records the data patterns emitted by standard infrared remote controls used by TVs, VCRs, Stereos, etc. Lets you control all your electronic projects with your TV remote. Seven individual I/O pins can be assigned to any button on your remote, and can be configured for either "toggle" or "momentary" action. $32.00

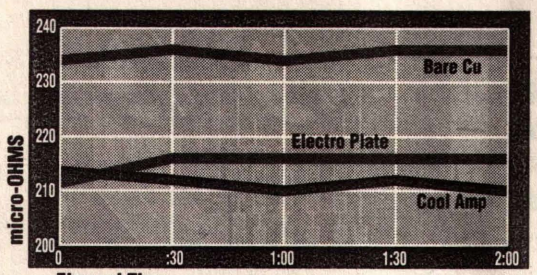
Vocal Filter
An audio device which can be used with a home component stereo system, to filter out the main vocal sound track from standard stereo recordings (CD, tape, record or FM), leaving the background music to sing along with. Produce your own karaoke tapes. $40.00

DTMF Decoder/Logger
Keep track of all numbers dialed or entered from any phone on your line. Connects to your telephone wall jack. Decodes all 16 touch-tones and displays them on an LCD display. Holds the last 240 digits in a nonvolitile memory. Scroll through and view all telephone numbers dialed, credit card numbers entered, etc. $54.50

In recent independent tests Cool-Amp is proven better than electroplating.

(For 50 years we've said Cool-Amp is "equal to" electroplating in performance. It is better.)

Cool-Amp

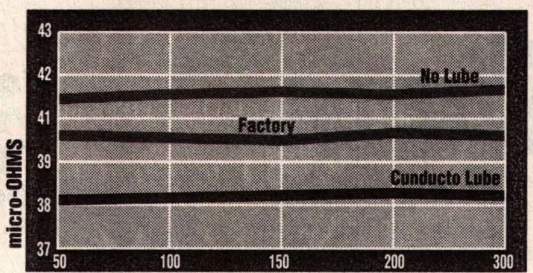


From the report:

"...compare the conducting properties of Cool-Amp silver plating compound with factory silver elctro-plated bus and bare copper bus.

"The test results indicated that the contact resistance of the Cool-Amp plated bus connection was slightly lower than that of the electro-plated bus connection and much lower than that of the bare copper bus connection. The final temperature at temperature equilibrium of the bus connection employing Cool-Amp was slightly lower than that of the electro-plated bus connection and the bare copper bus connection..."

Conducto-Lube



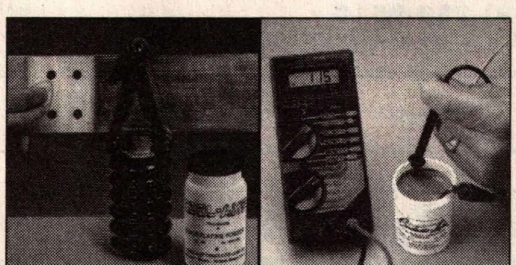
From the report:

"...compare the conducting properties of Conducto-Lube lubricant with factory lubrication and non-lubricated connections on an air switch. Identical test setups and procedures were used for each test so that comparative data could be collected and the relative performance of each type of connection could be quantified.

"The test results indicated that the contact resistance of the switch employing Conducto-Lube was generally lower than that of the factory lubricated switch and the switch that used no lubricant."

Cool-Amp How it works:

- Applies *on the job.* Application is simple. Yet Cool-Amp adheres permanently. As tests show, it is better than electroplating.
- Minimizes overheating and power loss by silver plating high amperage connections.
- Saves time, reduces maintenance. Cool-Amp is so simple to apply on the job. It assures maximum conductivity for copper, brass, or bronze contacts and prevents losses due to oxidation.



A one-pound bottle of Cool-Amp silver plating powder plates approximately 6,000 square inches.

Conductivity is demonstrated by inserting test prongs into a container of Conducto-Lube and establishing a circuit. Photo shows low voltage (115 VAC) continuity through container.

Conducto-Lube How it works:

- This is *the* conductive lubricant; highly conductive because it contains pure silver.
- Originally developed to lubricate switches, to the point tension can be adjusted to factory specs allowing full rated capacity of the switch to be maintained at all times.
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*Various tests were performed on both products in the Electro-Test, Inc. facilities in Portland, Oregon during January-March, 1994. Evaluation of plating thickness of Cool-Amp was performed by Surface Science Laboratories of Mountain View, California.

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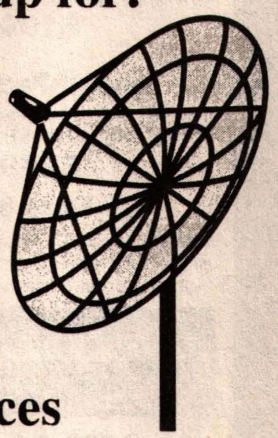

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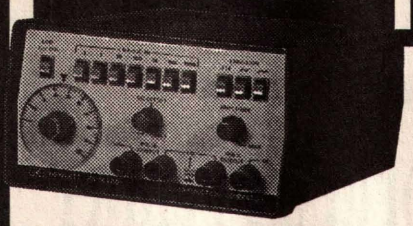

Hewlett-Packard 3311A

Function Generator, 0.1 Hz to 1 MHz, sine, square, triangle and + pulse waveforms.

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Fluke 1911A

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Hewlett-Packard 332A

Distortion Analyzer measures total distortion down to 0.1% full scale between 5 Hz to 600 kHz,

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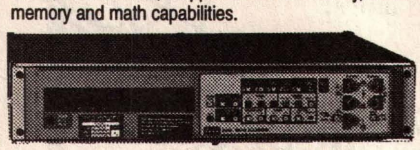
Fluke 8520A

Digital Multimeter, 5.5 digit, ac/dc volts, 2 and 4 wire ohms, conductance, 20 ppm basic dc accuracy, burst memory and math capabilities.



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275 MHz portable Oscilloscope, 10 mV/ div to 5V/div vertical deflection factor, 10 nS max sweep rate, expandable to 1 nS/ div. Includes 2 probes.

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Hewlett-Packard 1725A/034

As above, opt 034 adds DMM which measures voltage, current and resistance. Includes 2 probes.

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Tektronix 475A DM44 Oscilloscope

250 MHz bw, dual channel, 5 mV/ div sensitivity, 1nS/ div sweep rate. With differential-time/ DMM option. Includes 2 probes.

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Hewlett-Packard 239A

Oscillator provides a low distortion sine-wave output with >3 Vrms amplitude from 10 Hz to 110 kHz and less than -95 dB THD to 20 kHz.

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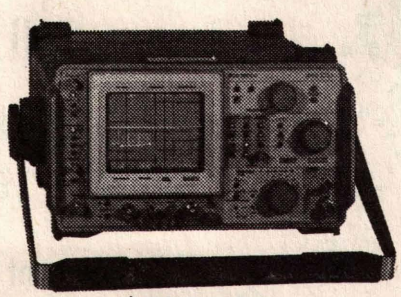
Tektronix 492 Spectrum Analyzer

50 kHz to 21 GHz, 80 dB dynamic range, amplitude comparison in 0.25 dB steps. Options 01, 02.



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Tektronix 7633 Oscilloscope

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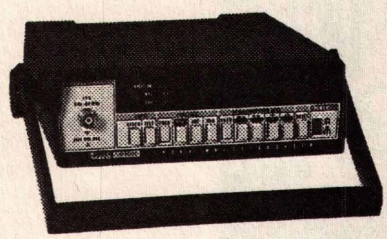

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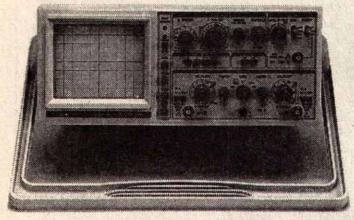

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Hide this attractive small size alarm in briefcases, medicine chests, drawers, cabinets, etc. and it will silently "stand guard". As soon as someone opens the briefcase drawer, cabinet, etc. it will start sounding a loud beeping sound. Operates on one 9V battery (not included) and uses a light sensitive IC circuit with built-in arming delay. The arming delay allows you 5 seconds to put the unit in a dark place after you arm it. Then, as soon as light strikes it (from someone opening the cabinet door etc.) the alarm sounds until it's once again in the dark. Great for warning you of intrusions into areas that children and intruders should stay out of. These have a Velcro® peel and stick piece on the back of each unit, that allows you to securely hold the unit to the back of a cabinet. Although these alarms are new, they were manufactured several years ago and the adhesive on the double stick velcro surface has dried out on the G6948 units which means on those units you'll have to use glue on the adhesive sides of the velcro if you wish to mount them (mounting is totally optional) The G6949 do not have this problem. Both types are electrically perfect it's only the velcro adhesive problem. Red plastic case is approximately 3" x 2 1/2" x 7/8"

G6948 (Bad Adhesive) $2.00
G6949 (Good Adhesive) $2.49

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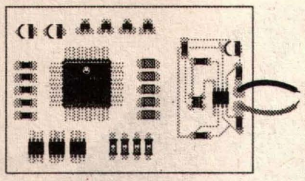


A great way to gain experience in soldering, identification and use of Surface Mount Device (SMD) Technology. Includes a practice section and a working LED flasher. Uses 9V battery (not included). Size of PC board: 2" x 3"

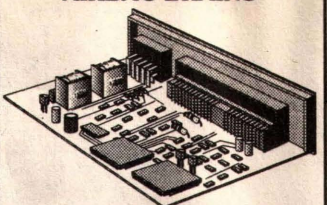
C6719 $8.69

TINY TRACKBALL

This is probably the tiniest trackball ever made! It measures only 1 11/16"L x 13/16"W x 3/8"H. Made by Alps for a major laptop computer maker that went out of business. They are very precision made and highest quality. The components are all SMD with an IC marked 3JA1DT002/TB6012CF and a tiny 8 position connector. They appear to be complete, new and very recent in manufacture. We have no hookup info or schematic, but at this price we know that you'll be impressed and want to experiment with them, use them for replacement or figure out the hookup! Hurry, these may not last long!

G5514 $1.50 ea.
10/$10.00

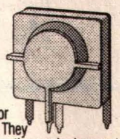
AIRBAG BRAINS



These are sophisticated airbag computer boards for automotive air bags. These have an incredible amount of SMD parts, microprocessor IC, various other ICs, SMD capacitors ,diodes, SMD transistors, SMD resistors, relay, regular resistors and capacitors. These are missing the airbag sensors (available below) and they, of course, are sold "as is" only. A few parts will be missing or damaged on each board. Great for study or for a source of parts for projects. Size: 5 1/4" x 4 1/4".

G6978 $1.00

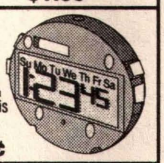
AIRBAG SENSOR (MECHANICAL TYPE)



Mechanical type precision sensor made for automotive airbag use. They contain a small metal ball which, upon the required amount of "G" force impact, causes a momentary short between two contacts. You can observe the process by connecting a simple circuit consisting of a battery and buzzer or LED to the contacts. If you "jar" the sensor sharply it will light the LED or cause the buzzer to sound momentarily. It seems like this sensor could be used in various unique circuits. Size: 1/2" square x 3/8" thick. Brand new but we have no info or data on it.

G6976 $1.00

DIGITAL CLOCK MODULE



Displays day of week, date & time. Brand new but battery is dead from storage.

G5911 79¢

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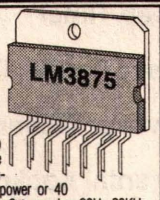

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G6943 $4.50

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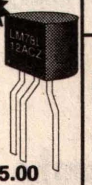

Prime TO92 case 78L12ACZ 12VDC IC. These are brand new but they have had their leads cut and formed for PC board use. Input voltage up to 35V. Maximum output current: 100mA.

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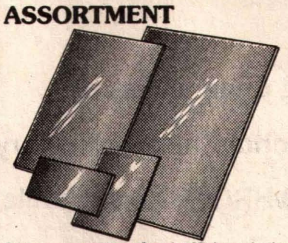

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G6967 $6.95

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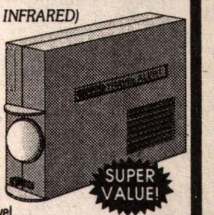

SUPER VALUE!

Brand new pocket-sized PIR alarm is perfect to take with you on vacations. Protect your hotel room, car, campsite vacation home, etc. The unit is called the Travel Alert by Snapit®. It detects people using a sensitive PIR detector, and sounds a loud electronic alarm when they intrude into its field of view. Compact unit is only 4" x 3" x 1 1/4". Operates on one 9V battery (not included).

G6954 $9.95
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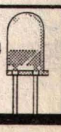
G7018 $3.95

LASER LIKE LEDS



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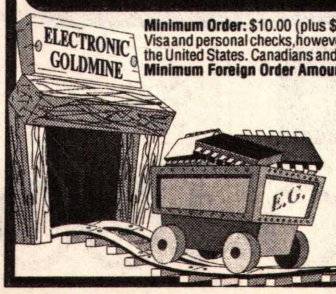

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Timeless Products TPI550PC w/G7 $139
Timeless Products TPI550PC with all new G7 Tri-Mode decoder installed. This brand new one piece system is a real crowd pleaser. Easy to install and operate.

SSA-TV86

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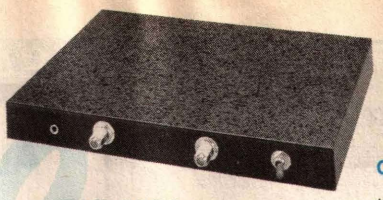

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- STD/HRC Switchable
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Stargate 550XL — $99 — $89

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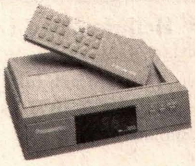
- Sleep Timer
- Last Channel Recall
- Favorite Channel Memory
- STD/HRC Switchable
- Channel 2/3 Switchable
- Infrared Remote Control

Panasonic TZPC1453G2 — $79 — $69

- Sleep Timer
- Last Channel Recall
- Favorite Channel Memory
- Parental Lockout
- STD/HRC Switchable
- Infrared Remote Control



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- Favorite Channel Memory
- Parental Lockout
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- Favorite Channel Memory
- Parental Lockout
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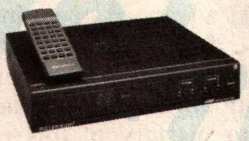
- Infrared Remote Control
- 100 Channel Capability



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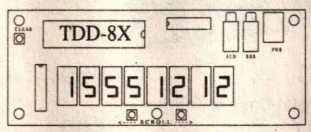
The TDD-8X features a large 8-digit LED display and decodes all 16 DTMF digits. The 104 character memory is viewed, without loss of data, by scrolling either left or right.



Although a computer is not required, the serial ASCII output allows automatic logging of decoded number groups. ToneLog™, our IBM/Compatible logging software is included. Available accessories include a Plastic Mounting Kit ($15), Audio/Computer Cables ($20) and a 12VDC AC Power Adapter ($10).

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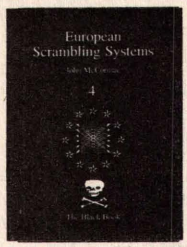

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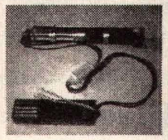

Includes 115VAC power supply manufactured by Laser Drive. These are pulls from equipment. Six month warranty. FREE "101 Uses for a He-Ne Laser." pamphlet. Cat. #: HE2
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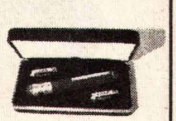

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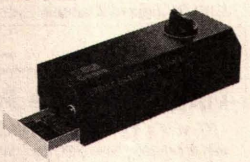

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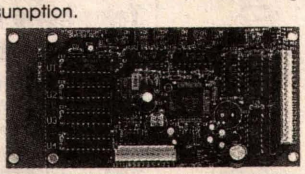
The DVM-58D has variable length message capabilities and can store up to 16 individual messages for immediate playback. Use it to add real voice prompting or instruction to any project, via the mic. input. Standard 1Mb DRAM on-board (32 sec.@ 32K bps) with options to expand up to 16Mb (8 min.@ 32K bps). ADM recording with selectable 16/32/44K bps sampling rates and very low power consumption.



#M105858 $89.95
1Mb DRAM $5.15
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RF TRANSMITTER + ENCODER MODULES

The TX-99 interfaces with the TX-01 as the RF carrier module. 300 MHz AM with a typical range of 50' -100' line-of-sight. (Key-chain transmitter is also available, model TX-99K $15.95)

#M109903 $5.95

The TX-01 Motherboard can encode a 12-bit address code with 4096 possible code combinations or can be used to encode an 8-bit address code with a 4-bit data code.

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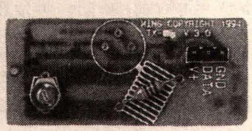

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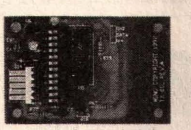

RF RECEIVER + DECODER MODULES

The RE-99 interfaces with the RE-01 as the RF carrier's receiver module and requires only a few solder connections to mate the two. 300 MHz AM.

#M109904 $6.95

The RE-01 Motherboard will decode a 12-bit address or 8-bit address with 4-bits of data, depending on which of the two included IC's is installed into the board.

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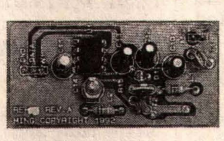

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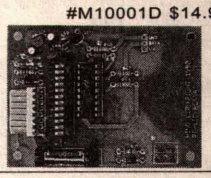
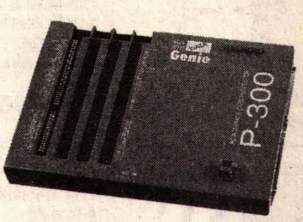


PC INTERFACE CARD PROTECTOR

The Data Genie P-300 is a device that allows quick and easy installation of add-on cards or prototype circuits for testing externally on your PC without having to turn off the computer. Maintains complete protection for your motherboard via the built-in protection circuitry & current limit fuses. Adds 3 expansion slots.



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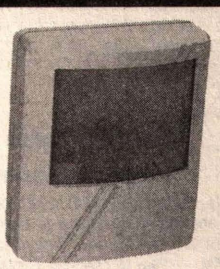

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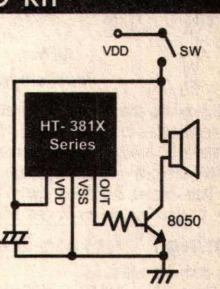

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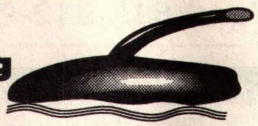

Remember War of the World? Objects float in air and move to the touch. Defies gravity, amazing gift, conversation piece, magic trick or great science project.

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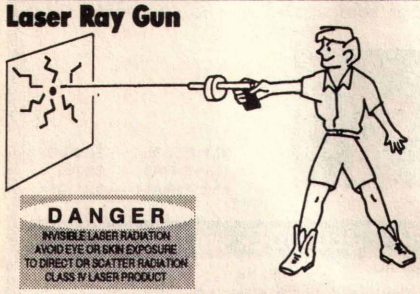

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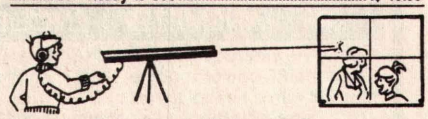

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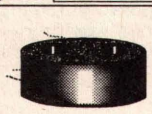

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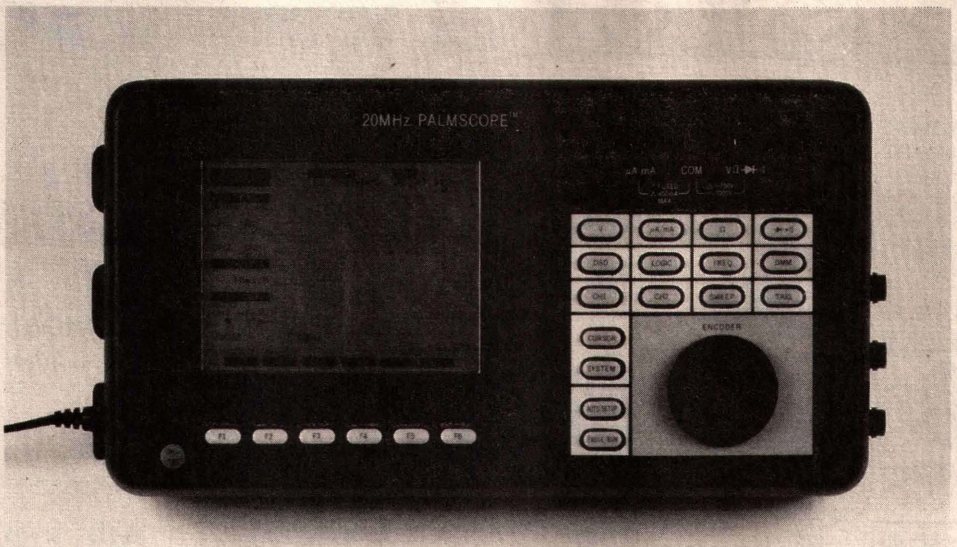
PALMSCOPE™ 320

ALL IN ONE DSO+DMM+LOGIC+COUNTER



Palmscope-320 features a 20Mhz DSO, 7 digit frequency counter, multimeter and logic scope. It can be operated with built-in battery for 3-4 hours typically. Built in RS-232 port and printer port extend your application. Optional software package is available.

PalmScope 320
$1695

DSO *• Dual channel digital storage oscilloscope (20 MS/sec) • Sensitivity range: 5mV / DIV - 20V / DIV • Sweep time: 50ns / DVI - 20s / DIV*

DMM *• Auto-range digital multimeter (4000 counts) • True RMS • DCV, ACV, DCA, ACA, Ohm Diode & continuity measurements*

LOGIC *• Logic Scope (8 channels, 50ns sample clock) • Selectable level: TTL/CMOS • Timing/State observation of logic signals*

COUNTER *•7 digit frequency counter (1 Hz to 20 MHz) • Selectable trigger level and FREQ/PER mode • Basic Accuracy ±10ppM*

General:
- Dual Channel Digital Storage Oscilloscope (20MS/s)
- Auto Range Digital Multimeter (3 3/4 digits, 4000 count)
- Frequency Counter (7 digits, 20 MHz)
- Logic Scope (8 channels, 50ns sample clock)

Display
- Number of Dots: 320(W)x240(H)
- Dot Pitch: 0.30 x 0.30 m/m
- Backlight: LED
- Data Out (RS-232C)
- Print Out: Portable Centronix and Epson Printer
- DC jack for AC adapter input
- LOW BATT Indicator

- Operating Temperature: 0°C to 40°C
- Operating Humidity: 0% to 70% R.H.
- Storage Temperature: -20°C to 70°C (0% to 80% R.H.)
- Dimension (LxWxH): 287x152x82 mm
- Weight: 2.0Kg
- Safety Compliance: it is designed to meet Class II per UL-1244, IEC 348 and VDE-0411

Introducing the Model #EDM-89S
5000 Count AUTO Range Digital Multimeter

Twelve Good Reasons To Buy The EDM-89S:
- 3-3/4 Digit, 5000 Count Digital Readout 50 Segment Analog Bargraph
- Auto/Manual, Dynamic Recording
- 0.1% DCV Accuracy, 20 kHz ACV Bandwidth, True-RMS AC Coupled
- 9999 Counts, 10 MHz Frequency Counter, Turbo Speed, and 50mF Capacitance Measurement
- dBm with Selectable Reference Impedance
- Dual Tone/Dual Display Logic Detection
- Relative Mode or Deviation Measurements
- Input Warning, Audible and Visible
- @ OFF Auto Power Off, Sleep Mode
- Overload Protection
- Audible Continuity/Diode Test
- Rugged Fire Retardant Case, Multipurpose Holster

MODEL #EDM-89S
$179.00

PRINT™ Products International

*8931 Brookville Road * Silver Spring, Maryland 20910 * 800-638-2020 * Fax 800-545-0058*

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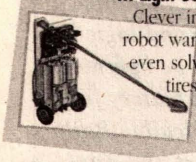
MONDO•TRONICS

Robot Store

Robot Kits!

Sonic Rover Robot #3-174 $27.95
A great, low-priced kit. Runs forward until it bumps object or hears loud noise, reverses, turns 90° & resumes. Molded body, red/green LED, great 48 page manual. Requires soldering. *An excellent first robot.* Two AA NiCads INCLUDED!

IR Light Sensing Robot #3-216 $68.95
Clever infrared sensors system lets this robot wander around & avoids objects - even solve mazes! Dual motors, rubber tires, preassembled gears & circuit board. *No Soldering Required!* Three AA NiCads INCLUDED!



Wall Hugging Mouse Robot #3-215 $29.95
Classic robot design escapes mazes using the "Left Hand Rule". Two motors & sensing switch guide it along walls and around corners. Preassembled gear box, plastic base & body. *No Soldering Required!* One C NiCad INCLUDED!

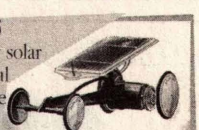
Mobile Robots Brains & Brawn Kit #3-148 $489.00
Serious research robot platform from MIT. Develop programs in C or assembly. Includes 68HC11 CPU, memory, sensors, wheels, motors, chassis, software. Companion to Mobile Robots book (3-098). *NOTE: Indicate PC or Mac interface.*

Adaptable Kits!

Power Shovel/Dozer #3-211 $39.95
An excellent full function robot base! Wire controlled left, right, forward, reverse, plus scoop up & down. Kit has extra track & other useful parts. Two D size NiCads INCLUDED!

Electric Piston Deluxe 5-Pack #3-137 $39.95
Incredible mini cylinders lift 1 pound! Just 10 cm long, shorten 23 mm with 1V, 5A. Cycles up to 6 times/min. Has five pistons, high current battery & full plans for 4 unique projects.

Solar Car Kit #3-217 $59.95
Run in the sun! High efficiency solar panel (0.5V, 1200 mAh), special high torque motor & adjustable gearing. Clean design!

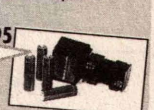


Batteries & Chargers

Earth Friendly - Wallet Friendly
High quality nickel-cadmium cells replace *hundreds* of disposables! Save money! reduce waste! Keep your robots rolling!

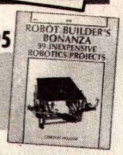
AA, 1.25V, 650 mAh	#3-269	$2.95
C, 1.25V, 1400 mAh	#3-270	$3.95
D, 1.25V, 1400 mAh	#3-271	$3.95
9V, 7.2V, 100 mAh	#3-272	$7.95

Special Charger, Quad AA #3-277 $14.95
Charge 1 or 2 pair of AA or one 9V cell. Ideal for all kits above. *BONUS - Includes 4 AA NiCds!*



Charger, 8 Position #3-276 $29.95
8 at a time! Fully charge up to 4 pairs of AAA, AA, C, D or up to four 9Vs - *in just 4 hours!*

Robot Builder's Bonanza #3-114 $17.95
Practical, ready-to-use circuits, devices, mechanisms, sources, tools, vision, grippers, navigation & more! 336 pgs.



Gadgeteer's Goldmine #3-129 $21.95
Unique high-tech projects & hard-to-find info. Robots, high voltage Tesla & Van de Graaff generators, Kirlian photos, lasers & much more! 400+ pgs.

Mobile Robots #3-098 $39.95
From MIT, a complete guide to designing & building robots: hardware, software, sensors, motors, "subsumption" software. 300+ pgs. A must for all roboticists.

Sensors for Mobile Robots #3-145 $59.95
Whoa! Everything about sensors: tactile, proximity, range, acoustic, laser, radar, microwave, path following, dead reckoning, compasses, gyros. Fun & intelligent!

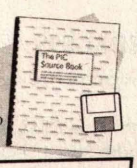
507 Mechanical Movements #3-173 $9.95
Reprinted from 1893 - when steam was king! Here are 100's of cams, clutches, linkages, latches, ratchets & more! *Don't reinvent the past - use it!* 120 pg. High powered!

The Robot Zoo #3-149 $19.95
A big, imaginative & fun book about animals that work like robots, or maybe they're robots that work like animals? 50 pages. *For kids of all ages.*

***Isaac Asimov's* Ultimate Robot CD-ROM $39.95**
Mac #3-135 or Windows #3-138
An incredible interactive collection of robot info, movie clips, demos & more. 100's of pictures, 50+ Asimov stories, animate on-screen robots. "Must have" resource all robot makers. *BONUS 12 pg "Explorer's Guide" FREE!*

Controlling the World With Your PC #3-165 $35.00
Convert ordinary serial & parallel ports into object-detecting, motor-spinning monsters! 42 circuits AND software in BASIC, C and Pascal! 256 pages, with PC disk.

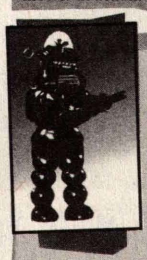
PIC Source Book #3-202 $39.95
Program PIC processors the easy way! Proven code to duplicate 30 BASIC functions - serial I/O, analog input, sound, 16-bit math, more. Adaptable to other processors! 104 pgs. w/PC disk.



Robotic Lawn Mower

WeedEater® VIP Robotic Solar Mower #3-224 $1,999.00
An astounding advance in robots & lawn maintenance. Sun powered, whisper quiet, safe, emission free! Range limited by buried wire boundary. Handles 1,450 m² (13,000 ft²), up to 20° slope. Frees you for other work *(or to build robots!)*

Video, Robotic Solar Mower #3-223 $4.95
See the Robotic Solar Mower in action! Shows robot in operation, blades, setup, even a time lapse sequence of the mower in action. 5 minutes, color, VHS NTSC only.



Robot Movies

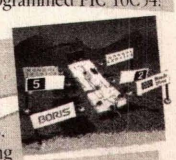
We found all our favorites & more! VHS-NTSC format (all U.S. systems.) Ratings in parenthesis.

Video Special Offers!
Buy any 5, take $10 off your total.
Buy any 10, take $25 off your total.

• *Classic Robot Films*		
Metropolis - *1926 (nr)*	#3-235	$29.95
Frankenstein - *Restored (nr)*	#3-250	$19.95
Forbidden Planet - *1956 (G)*	#3-233	$19.95
Day the Earth Stood Still *(nr)*	#3-251	$19.95
2001: A Space Odyssey *(G)*	#3-144	$19.95
Silent Running *(PG)*	#3-243	$19.95
• *Comedy Robot Films*		
Dark Star *(G)*	#3-231	$19.95
Sleeper *(PG)*	#3-244	$19.95
Young Frankenstein *(PG)*	#3-252	$19.95
• *Adventure Robot Films*		
Batteries Not Included *(PG)*	#3-255	$19.95
D.A.R.Y.L. *(PG)*	#3-258	$19.95
Short Circuit *(PG)*	#3-241	$19.95
Short Circuit II *(PG)*	#3-242	$19.95
Runaway *(PG-13)*	#3-240	$19.95
• *Action Robot Films*		
Alien *(R)*	#3-226	$19.95
Aliens *(R)*	#3-227	$19.95
Alien III *(R)*	#3-228	$19.95
Blade Runner - *Director's Cut (R)*	#3-256	$19.95
Battlestar Galactica *(PG)*	#3-229	$19.95
Logan's Run *(PG)*	#3-234	$19.95
RoboCop *(R)*	#3-237	$19.95
RoboCop II *(R)*	#3-238	$19.95
RoboCop III *(PG-13)*	#3-239	$19.95
Terminator *(R)*	#3-246	$19.95
Terminator II *(R)*	#3-247	$19.95
THX-1138 *(PG)*	#3-268	$19.95
Westworld *(PG)*	#3-248	$19.95
• *The Star Wars Trilogy*		
Star Wars (A New Hope) *(PG)*	#3-245	$19.95
Empire Strikes Back *(PG)*	#3-232	$19.95
Return of the Jedi *(PG)*	#3-236	$19.95
Mondo Robot Video Library	#3-267	$499.00

Get all 30 films & Save 18% - Over 50 hours of movies!!!

PICProto Demo Kit #3-180 $34.95
Discover PIC computer power. Quick & easy kit makes a variable speed metronome. PC board, speaker, parts & programmed PIC 16C54!



***Muscle Wires* Project Book & Deluxe Kit #3-168 $59.95**
Create direct linear *action* with Muscle Wires.™ They contract up to 5% when powered! For robots, models & anything needing strong all-electric motion. 128 page book, full plans for BORIS, a motorless walking robot & 14 others. One meter each 50, 100 & 150 µm dia Muscle Wires. Go!

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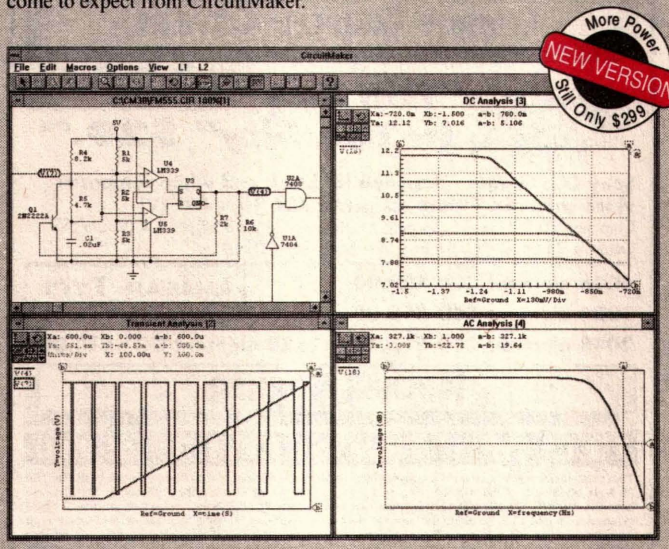
CircuitMaker®

The Complete, Low Cost, Circuit Design System

Professional Schematic Layout

CircuitMaker's schematic capabilities are unmatched and include many advanced editing features not found in similar programs. These powerful features minimize the time and task associated with drawing a schematic and insure a professional looking final product. Printout and export options are numerous and results are of the highest quality. But that's what people have come to expect from CircuitMaker.



Analog, Digital and Mixed-Mode Simulation

CircuitMaker's SPICE3 based analog simulation is fast and accurate. SPICE sub circuits for all base level digital devices provides advanced mixed-mode simulation capability. Digital simulation is live and highly interactive. This powerful simulation trio is tightly integrated into one package and will confirm your circuit designs with accuracy and ease.

Comprehensive Device Library

Version 3 features a state-of-the-art device browser which greatly simplifies the task of organizing and selecting devices. With its newly expanded device library, CircuitMaker now ships with more devices (at no additional cost) than any competing product. If you need a device that isn't provided, CircuitMaker provides industry standard SPICE import and a powerful Macro capability to enable you to create new devices. CircuitMaker provides you with the tools to get the job done right.

	Professional Schematic Capture	Mixed-Mode Simulation Features	Digital, Analog, and	1000+ Devices/Models	SPICE Export/Import	PCB Export	Retail Price
CircuitMaker	YES	YES	YES	YES	YES	YES	$299
Electronics Workbench version 4	YES	NO	YES	NO	NO	NO	$299
Electronics Workbench Engineer's Pack	YES	NO	YES	YES	YES	YES	$599

"CircuitMaker Shorts The Competition Out, With An Unbeatable Bottom-line"

Total Customer Satisfaction

At MicroCode Engineering we are committed to total customer satisfaction. When you purchase CircuitMaker you have the confidence of knowing that a trained staff of professionals is available to serve you after the sale. Our free unlimited customer service is second to none! Whether you have general or technical questions they will be answered promptly by a knowledgeable representative.

FREE Functional Demo

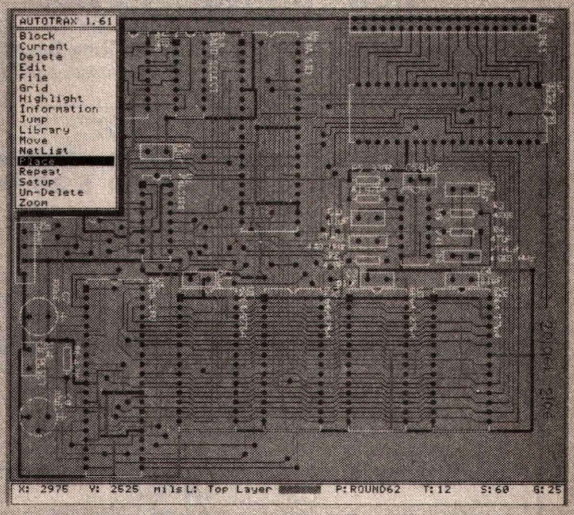
A free functional demo is available on the Internet (http://www.microcode.com), on CompuServe (GO MICROCODE) and on America Online (keyword search; CircuitMaker). A demo can be purchased directly from MicroCode Eng. for $10.

Printed Circuit Board Netlist Output

The PCB output capability helps you complete the design cycle, by generating a netlist that can be imported into any compatible PCB program. This is not a costly "add-on" product. It comes standard with every copy of CircuitMaker.

PCB Program

MicroCode Engineering also offers a CircuitMaker compatible, professional level, PCB layout and autorouting program for just $299. Used in conjunction with CircuitMaker, Autotrax completes a powerful end-to-end circuit design system. Call for details.



MicroCode Engineering
573 W. 1830 N. Suite 4
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FAX (801) 226-6532

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BLOWOUT! TIMELINE INC. BLOWOUT!

Over 9 years and 24,000 customers and still growing

Liquid Crystal Displays

160 x 128 dot LCD
with built-in controller (T6963C)

20 character x 16 line **$79.00** or 2 for $149.00

Mfr.: Toshiba TLX-1013-EO.

Unit is EL back-lit. Dim: 5 1/16"L x 4 1/16"H.

The built-in controller allows you to do text and graphics.

240x64 dot LCD with built-in controller. $79.00

Mfr: AND 4021ST-EO. *Unit is EL back-lit.* or 2 for $149.00

Alphanumeric—parallel interface

16x1 .....3 for $25.00	20x2 .....$12.00	40x1 .....$10.00
16x1 (lg. char.)....$12.00	20x4 .....$25.00	40x2 .....2 for $25.00
16x2 .....$8.00	24x2 .....$12.00	40x4 .....$25.00
16x2 (lg. char.)....$12.00	32x4 .....$15.00	4x2 .....$5.00
16x4 .....$15.00		

5V power required • Built-in C-MOS LCD driver & controller • Easy "microprocessor" interface • 98 ASCII character generator • *Certain modules are backlit, call for more info.*

Graphics and alphanumeric—serial interface

size	Mfr.	price	size	Mfr.	price
640x480 (backlit)	Epson	$50.00	480x128	Hitachi	$15.00
640x400 (backlit)	Panasonic	$35.00	256x128	Epson	$20.00
640x200	Toshiba	$19.00	240x128 (backlit)	Optrex	$20.00
480x128 (backlit)	ALPS	$15.00	160x128	Optrex	$15.00

Laser Products

HeNe Laser Head (10Mw max. output) TEMOO, 15.5" long MFG: NEC **$99.00**

Laser Power Supply (for HeNe tube) **$89.00**

Laser Scanner Assembly $29.00

Assembly intended for a laser printer. Includes laser diode, polygon motor (6 sided) and misc. optics and lenses.

LASER DIODE (5mW) with collimator **$20.00**

VISIBLE LASER DIODE: 5mw at 670nm **$15.00**
index guided. Threshold current 40 ma typical.

Network

IRMA BOARD 8 bit $99.00
Links 3270 mainframe systems to IBM PC

Proteon ProNet-4 Model p1347 Token Ring Board $79.00
16 bit • 4 Mbps • IEEE 802.2 and 802.5 compatible • twisted pair • interoperable with IBM Token Ring network

POS & Bar Code

MAGNETIC CARD READER *$25.00*

Includes: • 20 character dot matrix display with full alpha-numeric capability • keypanel with full alpha-numeric entry • separate 7.5 VDC/0.5 Amp power supply • standard telephone interface extension cord • lithium battery and flat-cone speaker.

HP bar code wand (HBCS 2300).....$35.00

Power Supplies

73 WATT SWITCHING $15.00 or 2 @ $25.00, (2) 4 pin power connectors attached • 115/230 Volt, Dim: 8.5" L x 4.5" W x 2" H • Output: +5V @ 2-9.75 A, +12V @ 0-1.5 A, -5V @ 0-0.4 A, -12V @ 0-0.5 A

68 WATT SWITCHING $12.00 or 2 for $20.00, 115/230 Volt, Dim: 5.5" L x 3.2" W x 1.7" H • Output: 5V @ 4 A, 12V @ 4A

Miscellaneous

ADAPTEC 4070A (RLL) OR 4000A (MFM) SCSI Controller, your choice $25.00

IBM 370 option XT and AT emulation boards $50.00

Monitors

Non-Enclosed TTL

Comes with pinout. 12V at 1.4 Amp input • Horizontal frequency 15Khz. • Ability to do 40 and 80 column.

5 inch Amber	$35.00
7 inch Amber	$39.00
9 inch Amber or Green	$29.95

5" COLOR MONITOR $49.00

- Flat Faceplate • 320 x 200 Dot Resolution • CGA & Hercules Compatible
- 12 VDC Operation • 15.75 KHz Horiz. Freq. • 60 Hz Vert. Sync. Freq.
- Open Frame Construction • Standard Interface Connector
- Degaussing Coil included • *Mfr. Samtron*

Charge Coupled Devices

"The Spy In The Sky" $29.00

MATRIX TYPE

Sony CCD Imager - designed for black and white composite video cameras. Picture elements: 384 (H) x 491 (V)
Chip size 10.7 (H) x 9.3 (V) mm² • Unit cell size 23.0 (H) x 13.4 (V) um².
Ceramic 24 pin DIP package • Mfr: Sony, Part# 016AL

LINEAR TYPE

4096 element CCD $29.00
1024 element CCD $15.00
2048 element CCD $15.00 • 1728 element CCD $15.00

Hacker Corner

CELL SITE TRANSCEIVER $99.00

These transceivers were designed for operation in an AMPS (Advanced Mobile Phone Service) cell site. The 20 MHz bandwidth of the transceiver allows it to operate on all 666 channels allocated. The transmit channels are 870.030-889.980 MHz with the receive channels 45 HMz below those frequencies. A digital synthesizer is utilized to generate the selected frequency. Each unit contains two independent receivers to demodulate voice and data with a Receive Signal Strength Indicator (RSSI) circuit to select the one with the best signal strength. The transmitter provides a 1.5 watt modulated signal to drive an external power amplifier. channel selection is accomplished with a 10 bit binary input via a connector on the back panel. Other interface requirements for operation are 26 VDC (unregulated) and an 18.990 MHz reference frequency for the digital synthesizer. The units contain independent boards for receivers, exciter, synthesizer, tunable front end, and interface assembly (which includes power supplies and voltage-controlled oscillator). Service manual, schematics and circuit descriptions included.

Encased Black & White Composite CCD Camera with Adapter
IR viewing to 1000 nm 7 ½ L x 2 ¾ W x 1 ¾ H
Comes complete with CCD camera, mounting nut on bottom of casing, 12VDC power supply. Excellent low light capability, standard RCA NTSC video out. **$89.00**

Great for: entryway security/remote monitoring, video conferencing/desktop video conferencing **2 for $159.00**

This miniature camera is perfect for multimedia computer applications as well as security and surveillance. NTSC output allows use with all popular video digitizing boards for Apple Macintosh and Microsoft video for Windows. Connects directly to any composite monitor or VCR with "video" input. Its razor-sharp wide-angle lens focuses from two inches to infinity and its state-of-the-art CCD technology accurately captures 16 level grayscale images for Quick Time movies and still pictures. Records at 30 frames per second and 260 lines resolution with excellent low light capability. Uses 12VDC (adapter supplied) and standard RCA cable.

Portable Micro Terminal

Flip up LCD display (9-16 VDC) • Can communicate with any computer having RS 232 port • Can communicate with another Microterminal • Use by itself as electronic notebook • Onboard microprocessor, data RAM (32K) and Video RAM (64K) • Complex built in diagnostics and set up capabilities. • Original intention for POS applications. • display size 40x16 (256 x 128 pixels.) Dimensions: 6.3" W, 11"L, 2"H. (With LCD up height is 7.1")

$99.00
or 2 for $149.00

BAREBONES 286-12 COMPUTER $49.00 (2 FOR $79.00)
Slimline desktop case, 100 watt supply, math co-processor support. On board IDE, & Floppy controllers. 2 COM ports and 1 parallel port with software setup. Supports up to 8 Megs using standard 30 PIN SIMMs. Internal room for (1) 3 1/2 inch IDE hard drive and (2) 3 1/2 inch floppies. Four 16 BIT ISA slots, accepts full length AT size cards. Keyboard can be set to no test at boot. Case size is 15.5"W x 16'D x 4"H.
(Motherboard can be purchased separately: $29.00 or 2 for $49.00)

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L.A. & Technical Info: **(310) 784-5488** Fax: **(310) 784-7590**
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Minimum Order: $20.00. Minimum shipping and handling charge $5.00. We accept cashiers checks, MC or VISA. No personal checks or COD's. CA residents add 8.25% sales tax. We are not responsible for typographical errors. All merchandise subject to prior sale. Phone orders welcome. Foreign orders require special handling. Prices subject to change without notice. 20% restocking fee for returned orders.

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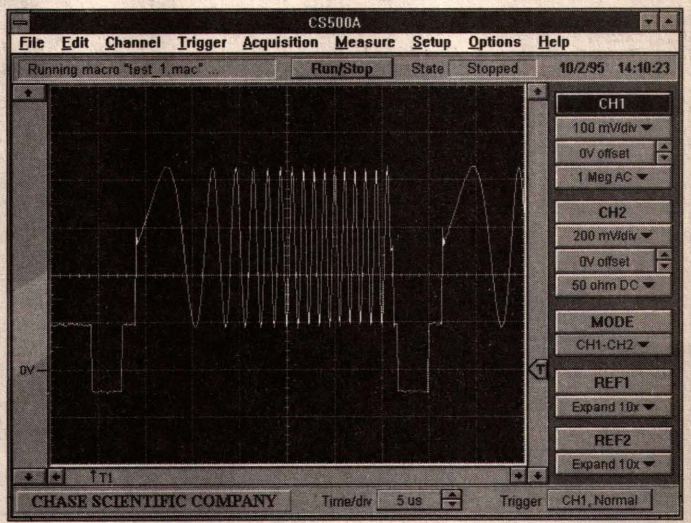
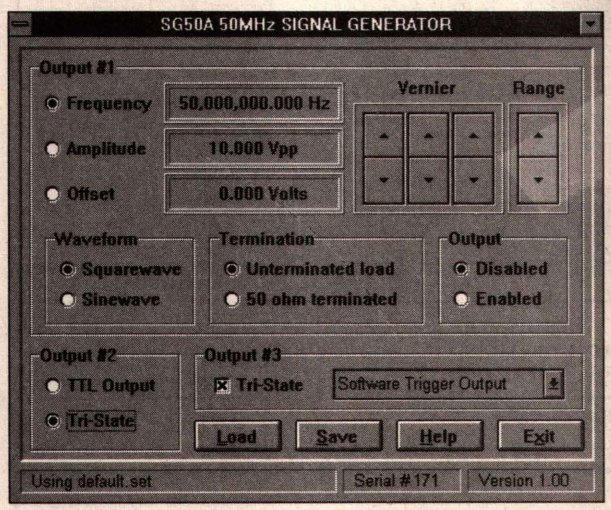
INNOVATORS IN VIRTUAL INSTRUMENTS — WINTER 1995-96, CATALOG NO. 3

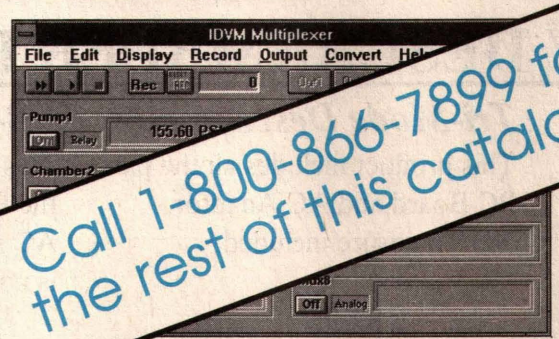
Our NEW 500 Megasample/sec PC-Based Digital Storage Oscilloscope offers wider bandwidths (>200 MHz), better triggering (10 levels of intelligent programmability), and MORE MEMORY than any other scope board (up to 8 MEG/ch). - See pg. 3.





This low cost synthesized Sine and Square wave generator produces signals from 0V to 10Vpp over a frequency range of 0.01 Hz to 50 MHz. Be sure to use our fax-on-demand for specifications that are not in this catalog. - See page 7.

Starting at $239, this 5.5 digit Parallel Port Voltmeter is more powerful than others costing 10x. For slightly more you get 48 input channels, perfect for those thermocouple projects - See page 2



Call 1-800-866-7899 for the rest of this catalog.

CONTENTS

48 Input 5.5 Digit Voltmeter Works Via Parallel Port

3 High Performance 500 Ms/s, 200MHz PC Oscilloscope

4 Low Cost 20 - 60 MHz PC-Based Oscilloscopes

5 PC-based 400 MHz Arbitrary Waveform Generator

6 PC-Based Logic Analyzer

7 Low Cost 50 MHz PC-Based Signal Generator

8 Desktop Temperature Chamber works via Serial Port

9 PC-Based Power Supplies

10 SuperProbes™ (8-18 input word/pattern recognizers)

11 Complete Fax-on-Demand System for PC (we use it !)

12 The *ULTIMATE* Windows™ Calculator (57+ different calculators in one)

NEW 400 Ms/s PC-BASED Arbitrary Waveform Generator Targeted for 2nd Qtr. 1996

With a 100MHz bandwidth, this is one of the fastest and finest Arbitrary Waveform Generators around. If you can't simulate your waveforms with this product, it probably can't be done.

Of course at $995, there isn't much competition. Why is it so cheap you ask? The answer isn't hard to figure out. We're not charging you for power supplies, cases, knobs, microprocessors, monitors, *and* Fortune 500 overhead.

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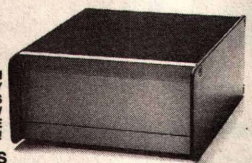
Tube & General Purpose Projects



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HIGH QUALITY CHASSIS FOR NEW TUBE PROJECTS!

LC SERIES

FIELD REMOVABLE TOP AND BOTTOM 0.080" ANODIZED ALUMINUM PANELS. FRONT & REAR PANELS 0.063" GOLD ANODIZED ALUMINUM; OTHER PARTS BLACK ANODIZED. VENTED CAGES & OAK ENDS AVAILABLE.

LC Series

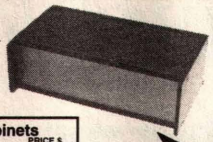
MODEL	SIZE (mm) W x D x H	PRICE $ A	B
LC-1	100 x 100 x 50	45.00	47.50
LC-2	150 x 100 x 50	50.00	52.50
LC-3	200 x 100 x 50	55.00	57.50
LC-4	300 x 100 x 50	60.00	62.50
LC-5	150 x 150 x 75	50.00	54.00
LC-6	200 x 150 x 75	55.00	59.00
LC-7	300 x 150 x 75	60.00	64.00
LC-8	400 x 150 x 75	65.00	69.00
LC-9	200 x 200 x 75	60.00	64.00
LC-10	250 x 200 x 75	65.00	69.00
LC-11	300 x 200 x 75	70.00	74.00
LC-12	425 x 200 x 75	75.00	79.00
LC-13	250 x 250 x 100	70.00	76.00
LC-14	300 x 250 x 100	75.00	81.00
LC-15	350 x 200 x 100	80.00	86.00
LC-16	425 x 250 x 100	85.00	91.00

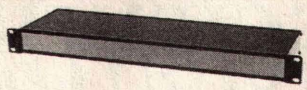
ALL HARDWARE SUPPLIED.

SESCOM BOXES ARE USED BY HUNDREDS OF CONTRUCTORS!

USE IS LIMITED ONLY BY YOUR IMAGINATION!

NEW LARGER SIZES





Metal Cabinets

MODEL	W x D x H (IN)	PRICE $ A	B
MC-1A	4 x 3 x 2	12.00	14.00
MC-2A	6 x 3 x 2	14.00	16.00
MC-3A	8 x 3 x 2	16.00	18.00
MC-4A	4 x 5 x 3	14.00	16.00
MC-5A	6 x 5 x 3	16.00	18.00
MC-6A	8 x 5 x 3	18.00	20.00
MC-7A	4 x 7 x 4	16.00	18.00
MC-8A	6 x 7 x 4	18.00	20.00
MC-9A	8 x 7 x 4	20.00	22.00
*MC-10A	8.5 x 7 x 1.75	32.00	34.50
*MC-11A	8.5 x 10 x 1.75	34.00	36.50
*MC-12A	8.5 x 14 x 1.75	36.00	38.50
*MC-13A	8.5 x 7 x 3.5	33.50	36.00
*MC-14A	8.5 x 10 x 3.5	35.50	38.00
*MC-15A	8.5 x 14 x 3.5	37.50	40.00
*MC-16A	17 x 7 x 1.75	34.50	38.00
*MC-17A	17 x 10 x 1.75	36.75	40.25
*MC-18A	17 x 14 x 1.75	42.75	46.25
*MC-19A	17 x 7 x 3.5	36.75	40.25
*MC-20A	17 x 10 x 3.5	39.25	42.75
*MC-21A	17 x 14 x 3.5	45.25	48.75

EXTRA PAIR FRONT/REAR PANELS 5.00 7.50

WOW, DO WE HAVE BOXES!

SESCOM ALSO STOCKS ALL KINDS OF USEFUL PARTS FOR CONSTRUCTION INCLUDING CONNECTORS, SCREWS, METERS, TOOLS, ETC.

Rack Chassis

MODEL	W x D x H (IN)	PRICE $ A	B
1RU5	19 x 5 x 1.75	34.00	44.00
1RU7	19 x 7 x 1.75	36.50	48.50
1RU10	19 x 10 x 1.75	38.75	50.00
1RU12	19 x 12 x 1.75	42.75	56.00
1RU15	19 x 15 x 1.75	45.75	58.00
1RU17	19 x 17 x 1.75	48.75	60.00
2RU5	19 x 5 x 3.5	36.50	46.50
2RU7	19 x 7 x 3.5	38.75	50.75
2RU10	19 x 10 x 3.5	41.25	53.00
2RU12	19 x 12 x 3.5	45.25	58.25
2RU15	19 x 15 x 3.5	48.25	60.50
2RU17	19 x 17 x 3.5	51.25	62.50
3RU5	19 x 5 x 5.25	46.00	56.50
3RU7	19 x 7 x 5.25	48.50	60.75
3RU10	19 x 10 x 5.25	51.00	63.00
3RU12	19 x 12 x 5.25	54.00	68.25
3RU15	19 x 15 x 5.25	57.00	70.50
3RU17	19 x 17 x 5.25	60.00	72.50

EXTRA PAIR FRONT/REAR PANELS 7.50 9.00

Audio Transformers for Tube Construction

Inputs – Line/Mic

MODEL	PRI Ω	SEC Ω	CASE STYLE	USE	PRICE $ A	B
AT-1	150	60k	A	MIC INPUT	40.50	42.50
AT-2	15k	15k	A	LINE INPUT	40.50	42.50
AT-3	15k	600	B	LINE OUTPUT	46.75	48.50

Tube Outputs

OT-1	5k	8	B	EL84 3 WATT	9.00	11.00
OT-2	6k	4,8,16	B	EL84 10 WATT	12.00	16.00
OT-3	7k	4,8,16	B	EL34 20 WATT	18.00	24.00

ULTRA LINEAR DESIGN

OUTPUT TRANSFORMERS DESIGNED FOR SIMPLE OUTPUT STAGES AND FEATURE FREQUENCY RESPONSE ±2 dB 40-15k Hz.

Power Supply

MODEL	SECONDARY #1	#2	#3	CASE STYLE	USE	PRICE $ A	B
PT-1	125V/ 25mA	6V3/ 3A			B	PRE AMP	9.00 11.00
PT-2	250-0-300 40mA	5/ 2A	6V3/ 2A	B		5W AMP	18.00 24.00
PT-3	300-0-300 70mA	5/ 2A	6V3/ 2A	B		10W AMP	20.00 26.00
PT-4	400-0-400 180mA	5/ 3A	6V3/ 4A	B		20W AMP	24.00 30.00

Pots

PART #	Ω	TYPE	PRICE $ A	B
APOT-1	100k	S LIN	2.75	3.00
APOT-2	100k	S LOG	2.75	3.00
APOT-3	100k	D LIN	5.50	6.00
APOT-4	100k	D LOG	5.50	6.00
APOT-5	470k	S LIN	2.75	3.00
APOT-6	470k	S LOG	2.75	3.00
APOT-7	1M	S LIN	2.75	3.00
APOT-8	1M	S LOG	2.75	3.00
APOT-9	1M	D LIN	5.50	6.00
APOT-10	1M	D LOG	5.50	6.00
APOT-11	100k	D LOG (FOR BALANCING)	6.50	7.00

MOUNTING HOLES 10mm (.393") DIA.; SHAFTS 6mm (.236") DIA., BLACK MATTE KNOBS 15mm (.590") DIA. X 14mm (.551") SUPPLIED.
S = SINGLE D = DUAL

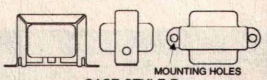
Sockets

PART	TYPE	PRICE $ A	B
TS-1	7 PIN S	1.90	2.10
TS-2	7 PIN P	1.90	2.10
TS-3	9 PIN S	1.90	2.10
TS-4	9 PIN P	1.90	2.10
TS-5	8 PIN OCTAL S	2.50	2.70
TS-6	8 PIN OCTAL P	2.50	2.70

GENERAL PURPOSE SOCKET TYPES, FULL MOUNTING DETAILS INCLUDED IN CATALOG TB-1.
S = SOLDER P = PC MOUNT

3/8"-32 THROUGH BUSHING

CASE STYLE A



MOUNTING HOLES

CASE STYLE B

MENTION AD AND TAKE 5% OFF YOUR FIRST ORDER!

FOR MORE INFO REQUEST CATALOG TB-1

GREAT LITTLE BOXES FOR LOW COST CONSTRUCTION

DESIGNED TO GET THE JOB DONE WITHOUT THE FRILLS!

NEW

MINI PROJECT BOX

ALTHOUGH NOT DESIGNED FOR TUBE CONSTRUCTION, THESE ARE VERY USEFUL IN LABS. DESIGNED WITH SIX 0.040" FLAT RAW ALUMINUM PANELS AND MICRO EXTRUSION.

Mini Project Boxes

MODEL	SIZE (IN) W x D x H.	PRICE $ A	B
MPB-1	1 x 2 x 1	1.95	2.25
MPB-2	1 x 4 x 1	2.40	2.75
MPB-3	1 x 6 x 1	2.85	3.25
MPB-4	1.5 x 2 x 1.5	2.05	2.25
MPB-5	1.5 x 4 x 1.5	2.55	2.85
MPB-6	1.5 x 6 x 1.5	3.00	3.60
MPB-7	1.5 x 2 x 3	2.25	2.55
MPB-8	1.5 x 4 x 3	2.75	3.15
MPB-9	1.5 x 6 x 3	4.00	4.50
MPB-10	1.5 x 2 x 5	2.50	3.00
MPB-11	1.5 x 4 x 5	2.95	3.55
MPB-12	1.5 x 6 x 5	4.25	5.05
MPB-13	2 x 2 x 2	2.20	2.60
MPB-14	2 x 4 x 2	2.65	3.15
MPB-15	2 x 6 x 2	4.40	5.00
MPB-16	2 x 8 x 2	6.65	7.35
MPB-17	3 x 2 x 3	2.45	2.95
MPB-18	3 x 4 x 3	2.90	3.50
MPB-19	3 x 6 x 3	4.20	4.90
MPB-20	3 x 8 x 3	4.85	5.45
MPB-21	4 x 6 x 3	4.55	5.15
MPB-22	4 x 10 x 3	4.75	5.45
MPB-23	4 x 12 x 3	5.70	6.30
MPB-24	4 x 14 x 3	6.10	6.80

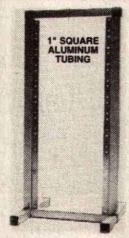
PERFORATED OR PLEXIGLASS PANELS ALSO AVAILABLE

RACKEM 'N' STACKEM
Table Top Racks

MODEL	HEIGHT IN RACK UNITS	PRICE $ A	B
RSR-5-19	5	70.00	80.00
RSR-6-19	6	75.00	87.50
RSR-10-19	10	70.00	80.00
RSR-12-19	12	70.00	80.00

CLEAR FINISH STANDARD: ADD /B FOR BLACK OR /G FOR GOLD.

PICTURED WITH OPTIONAL RE-1 RACK EARS



RACKEM 'N' STACKEM
BOXES

MODEL	W x D x H (IN)	PRICE $ A	B
RSB-3	7.5 x 3 x 1.65	25.00	30.00
RSB-5	7.5 x 5 x 1.65	31.25	36.25
RSB-7	7.5 x 7 x 1.65	38.00	43.00
RSB-9	7.5 x 9 x 1.65	45.00	50.00
RSB-11	7.5 x 11 x 1.65	51.50	56.50
RSB-13	7.5 x 13 x 1.65	58.25	63.25

ASSORTED MOUNTING ACCESSORIES ALSO AVAILABLE

ALL BOXES ARE SHIPPED FLAT FOR EASY FABRICATION

UNLESS OTHERWISE NOTED BOXES HAVE FLAT PANELS CONSTRUCTED OF 0.063" ANODIZED ALUMINUM (SIDES ARE 0.125") FRONT AND REAR PANELS ARE CLEAR, BALANCE OF BOX IS BLACK. BLACK OR GOLD FRONT & REAR AVAILABLE FOR AN ADDITIONAL $5.00.

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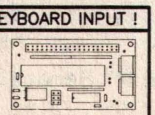

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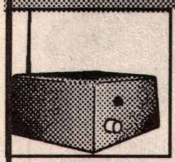


FM STEREO TRANSMITTER

Own your own FM radio station. Any stereo signal you plug into the FMST-100 will be transmitted to any FM radio tuneable from 76 to 108MHz FM. Transmit a wireless link through an auditorium, from your car to your camper, listen to your CD's while mowing the lawn, Play music on one channel sing on the other. Clarity is excellent, aprox. 40dB stereo separation. Length of antenna determines the distance of transmission. Complete with stereo input level controls & crystal for stereo separation. 9v battery operation. SIZE: 1.5" x 2.5" x 3"

FMST-100 KIT **$29.95** / Cabinet **$8.95**

PHONE TRANSMITTER

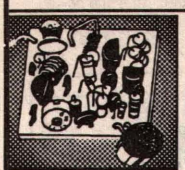
Small but mighty,it fits anywhere. Phone line powered, never needs batteries. Transmits both sides of a phone conversation loud and clear, wireless, to any FM radio at great distances. Variable tunes from 70MHz to 130MHz FM. You can also use it as a speaker phone. SIZE:1.25" x .6".

TEL-B1 KIT **$12.95** BUILT **$29.95**

SUPER SNOOPER BIG EAR

Listen through walls, hear conversations across the room. Add a parabolic reflector and hear blocks away. The BIG EAR can be hidden about anywhere. Makes an ultra sensitive intercom. Can be used as a 1.5W AMP. We supply a mini-electret mike in the kit. Power requirement 6 to12v DC SIZE:1.75" x 1"

AA-1 KIT **$10.95** BUILT **$29.95**



WIRELESS FM MICROPHONE

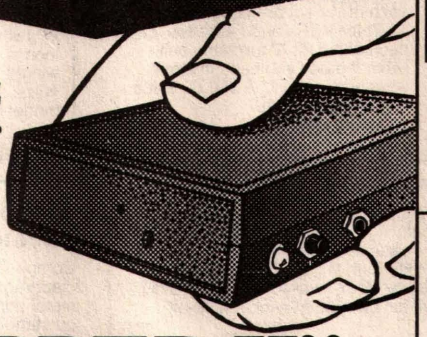
Small but mighty this little jewel will out perform most units many times its price. It really stomps out a signal. The WM-1 kit is a buffered wireless mike that operates from 80MHz to 120MHz FM, the frequency of any broadcast FM radio. Includes a mini-electret mike. 6 to 12v DC. SIZE: 1.25" x 1"

WM-1 KIT **$14.95**

DC VOLTAGE MONITOR

If battery status is important, you need this kit. This kit uses 7 LEDs to monitor 12v DC in 1v, 1/2v, or 1/4v steps. Monitor 8v or 5v in 1/4v steps. Great for boats, motor homes, model planes or race car ni-cads. All parts and instructions are included. SIZE: 1.3" x 2.7".

VM-1 KIT **$7.95**



The 10GHz Transmitter is back...

The "ZAPPER II"

With it's new and improved design it will not only test your radar detector... BUT it's tuned to the amateur radio band.

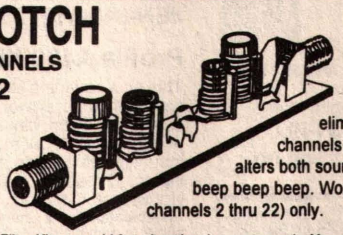
- While your out on American highways personally test yours and your fellow travelers radar detectors.

The "ZAPPER II" is a 10.450 GHz to 10.550 CW oscillator. It has a code key jack installed for those who want to send Morse code.

BUILT **$49.95** KIT **$39.95**

TV NOTCH FILTERS

FOR CHANNELS 2 thru 22 ONLY



Our TV filters eliminate unwanted TV channels or interference that alters both sound and video with a beep beep beep. Works on cable channels 2 thru 22) only.

NOTE: All TV Filter Kits are sold for educational purposes only. You must obtain permission from your local cable company before using these filters on your cable system.

DF-222 KIT **$14.95**

This Manual contains schematics, parts lists & P.C. board layouts for many of the Rainbow Kits. Use your own parts to construct our kits.

KIT BOOK

$14.95 **$9.95** with the purchase of any kit.

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STROBE LIGHT

Do you need an attention getter, warning light,or flashing light for model airplanes? Then this kit is for you. Use it as an emergency light for your auto, radio tower, even use it on your bicycle. Has a variable flash rate. Power requirement 6 or 12v DC . Size 3.5"x1.9"

ST-1 KIT **$9.95**

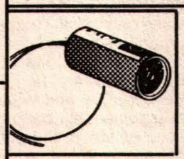
MICRO-LIGHT

Visible Over 1 Mile.

This is truly an indestructible flash light.

- Comes in red or yellow light.
- Bulb will not burn out.
- Uses a 5 year shelf life lithium battery.
- Case made of tough ABS.

MLR (red light)
MLY (yellow light) CHOICE **$9.95**



4.0 mW Laser Diode

Great for making a gun sight, use as a transit, makes a super experimenters project. The beam is visible with a wavelength of 670 nm. Size of beam is 6mm at 5 meters. Power requirement 3 volts DC at 85mA. Size: 10.5mm x 18.5mm

LDM-5 New Low Price **$59.95**

VOICE ACTIVATED SWITCH

This VOX circuit can be used to operate a tape recorder, ham radio, CB radio, or turn on an alarm. The VOX-1 kit has 100MA of output that operates a relay, light, motor, ? What could you do with a sound activated switch?Power requirement 7.5 TO 18vDC. SIZE: .1.5" x 1.3"

VOX-1 KIT **$6.95**

WIDE BAND PREAMP

The ideal preamp for scanners, hand held radios, frequency counters. Amplifies low level (weak) signals. If the signal is extremely low 2 amps can be used in series. 1MHz to 2.5GHz @ 2.8dB NF. 1dB compression = +0 dBm. Gain: 1MHz=20dB to 2.5GHz=6dB. Power requirement 12v DC @ 6Ma. SIZE: 1.2" x .8"

WBA-6 KIT **$19.95**

CIRCLE 242 ON FREE INFORMATION CARD

Parts Express™

Cellular Phone Battery For Motorola

6V, 700 mAH replacement battery for Motorola flip phones. Dark grey color.

#EN-140-860 ..... **$23.50**(1-5) **$21.25**(6-UP)

Flip Phone Saver/Charger

Plug-in saver/charger for Motorola flip phones. Lifetime manufacturer warranty.

#EN-141-400 ..... **$19.95**(1-5) **$16.95**(6-UP)

201 PanaVise Jr.

This mini vise is a invaluable bench top companion for the home hobbyist. PV Jr. uses the famous PanaVise design that turns, tilts, and rotates for a full range of movement. Ideal for soldering, gluing, and general work. Features jaws that open to 2-7/8", both vertical and horizontal grooves to hold work, and a fine adjustment knob. Net weight: 1 lb. 4 ozs.

#EN-365-300 ..... **$19.95**EACH

Drive Belt Kit

We've selected 18 of our most popular VCR, cassette and turntable belts to include in this kit. 87 belts total, five each of 17 square belts from 2.3" to 13.2" for VCRs and cassettes, and 2 each of the 23.6" turntable belt. Have the belt you need in stock when you need it. A $50.00 value. Net weight: 1/4 lb.

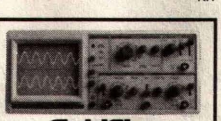
#EN-400-910 ..... **$29.95**KIT

Pioneer 8" Woofer with Butyl Surround

8" paper cone woofer with a butyl rubber surround. Butyl rubber is extremely flexible and resists moisture better than foam. Half roll suspends the outside edge of the cone to allow distortion free sound.
◆Power handling: 80 watts RMS/150 watts max. ◆Voice coil diameter: 2 inches ◆Impedance: 8 ohms ◆Frequency response: 31-7000 Hz ◆Magnet weight: 30 ozs. ◆SPL: 91 dB 1W/1m ◆VAS: 2.44 ◆QTS: .26 ◆XMAX: .110 ◆QES: .27 ◆QMS: 6.51 ◆FS: 31 Hz ◆Net weight: 7 lbs. ◆Manufacturer model number: B20GR30-51F-Q. ◆Hole to hole: 7-3/4".

#EN-290-042 ..... **$34.50**(1-3) **$29.95**(4-11) **$28.45**(12-UP)

Goldstar 20MHz Oscilloscope



The OS9020A combines both high quality and low cost, making it ideal for educational, industrial, and hobbyist applications. Features include: DC-20MHz analog bandwidth ◆6" high luminance CRT ◆Dual channel, dual trace ◆Max sweep time of 20nS/div ◆Trigger level control ◆Separate circuit for TV sync ◆Variable hold-off function.
SPECIFICATIONS: Vertical: Deflection factor: 5mV/div to 5V/div in 10 calibrated steps. Rise time: 17.5nS or less. Max input voltage: 250V (DC/peak AC). Modes: CH1, CH2, ADD, DUAL.
Horizontal: Sweep time: 0.2uS/div to 0.2S/div in 19 calibrated steps. Modes: X1, X10, X-Y.
Trigger: Modes: Auto, Norm, TV-V, TV-H. Source: CH1, CH2, LINE, EXT.
GENERAL: Dimensions: 12-1/2"W x 5-1/2"H x 16-3/4"D. Net weight: 16-1/2 lbs. Acceleration potential: 2KV. Power requirements: 100V/120V/220V/240V, 50/60 Hz. Comes complete with power cord, (2) 10:1 probes, and manual.

#EN-394-100 ..... **$385.00**EACH

Audax 1" Titanium Composite Dome Tweeter

Composed of pure titanium deposited on a polymer diaphragm, this composite offers the exceptional detail of metal domes while retaining the smoothness of soft domes. The result is outstanding clarity, low distortion and very high efficiency.
◆Power handling: 70 watts RMS/100 watts max. ◆Voice coil diameter: 1 inch ◆Impedance: 8 ohms ◆Frequency response: 2500-20,000 Hz ◆Magnet weight: 8-1/2 ozs. ◆Fs: 1500 Hz ◆SPL: 93 dB 1W/1m ◆Net weight: 1 lb. ◆Manufacturer model number: TW025M3 ◆Hole to hole: 3-3/8".

#EN-276-070 ..... **$37.90**(1-3) **$34.75**(4-11) **$31.80**(12-UP)

The Wet Look™

The Wet Look™ is a new generation of high gloss polymers formulated especially for the speaker industry. This superior coating provides a protective "coat of armor" for your paper cone speakers. A special U/V inhibitor has been added to reduce the decaying effects of the sun's ultraviolet rays. The Wet Look™ makes paper cones resistant to water, humidity, sun, and salt. Best of all, it's easy to apply and cleans up with soap and water. 1 pint can.

#EN-340-510 (Clear) **$8.95**EACH
#EN-340-512 (Black) **$8.95**EACH

Computer Monitor Testers

These compact devices can quickly and easily troubleshoot, test, and align computer monitors, without the need for a separate computer. The #390-705 is used to test EGA, VGA, SVGA, VGA-8514A and VESA monitors. The #390-700 is used to test MDA, CGA, EGA, VGA, SVGA, and VGA-8514A monitors. Generates the following video test patterns: color bars, cross hatch, dots, color raster (white, red, green, blue), and windows. Two video connectors are provided: a digital/TTL 9 pin and an analog 15 pin. The testers may be powered by either a 9V battery or an external AC adaptor (not included). Dimensions: 1-1/2" x 3-5/16" x 5-5/8". Net weight: 3/4 lb.

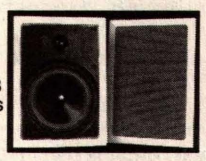
#EN-390-700 (Standard Monitor Tester) **$149.00**EACH
#EN-390-705 (Monitor Tester w/High Res. VESA) **$149.00**EACH

Profile A400 XL 2 Channel, 100 Watt Amplifier

This nice sounding MOSFET stereo amplifier gives you plenty of output power for the money. Includes built-in subwoofer boost, class AB operation, power light strip, bridgeable to 200W mono, thermal protection, variable input sensitivity, gold plated RCA and speaker level inputs. Dimensions: 8-1/4"(W) x 2-1/4"(W) x 8-1/2"(D). Net weight: 6-1/2 lbs.
Specifications: ◆2 Channel: 100W x 100W RMS (4 ohm load/.05% THD) ◆Mono: 200W (4 ohm load/.05% THD) ◆Subwoofer boost frequency: 80 Hz ◆Signal to noise: 100 dB ◆Channel separation: 60 dB ◆Damping factor: 200 ◆Output current: 10 amps per channel max.

#EN-265-136 ..... **$143.50**EACH **$132.80**(2-UP)

6-1/2" Two Way System



This is our most popular in-wall. The 6-1/2" polypropylene woofer and 1" textile dome tweeter were specially designed with home theater in mind. 3 piece design make installation in new or existing walls a snap. Textured ABS frame and steel mesh grill are spray paintable to match (or blend into) any decor. System comes with speaker assembly, removable metal grill, heavy steel backer plates, screws and hardware, hole cut-out template, paint mask, and detailed installation instructions.
Specifications: ◆6-1/2" polypropylene cone woofer with poly foam surround. ◆1" textile dome tweeter/midrange. ◆8 ohm impedance. ◆3 component L/C crossover network. ◆Frequency response: 50-20,000 Hz. ◆Power handling capability: 60 watts RMS/100 watts max. ◆Sensitivity: 89 dB 1W/1M. ◆Overall dimensions: 8-1/2" W x 12" L x 3-1/2" D. ◆Hole size: 7-1/4" x 10-3/4". ◆Fits into standard 2" x 4" wall. ◆Net weight: 12 lbs. per pair.

#EN-300-036 .. **$104.95**(1-3 PRS) **$96.50**(4-11 PRS) **$85.50**(12 PRS-UP)

Bulldog Model 7002PRO Alarm

The 7002 Pro utilizes a sophisticated microprocessor to offer these technologically advanced features: (2) two remote controls, 6 tone 127 dB siren, keyless entry, active arming, programmable passive arming with doors locking, programmable 30 second chirp, anti-car jacking feature, valet mode, dual stage shock sensor, instant panic, negative and positive door pin trigger inputs, automatic 35 second alarm reset, starter kill relay and socket, 6 function LED status, remote car finder, 2 negative outputs, 30 second last door arming, silent arming/disarming, and arm/disarm confirmation chirp. Lifetime limited factory warranty. Made in the U.S.A. Net weight: 2 lbs.

#EN-330-312 ..... **$99.95**EACH

12 Ga. Sound King Speaker Wire

Super flex, extra soft 60°C clear PVC insulation. Transfers music signals from the source to the speakers with high definition and clarity. Oxygen free, bare copper rope lay construction. Made in the U.S.A. ◆AWG: 12 ◆Construction: 259 x 36 Ga.

#EN-100-155 (100 ft. spool) ..... **$39.90**(1-3) **$34.90**(4-UP)

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CIRCLE 262 ON FREE INFORMATION CARD

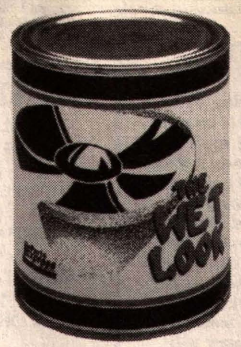
Parts Express™

3-In-1 Universal Remote

This remote will operate any remote controlled cable box, TV or VCR at just a fraction of the cost of a factory replacement! This unit is already preprogrammed to include the most common codes. It is attractively styled, durable, and easy to set up and operate. The manufacturer even offers a toll free consumer help line to answer questions and provide customer assistance. Requires 2 AAA batteries (not included).

#EN-180-565 ..... 11.95_{(1-9)}$ 9.95_{(10-UP)}$

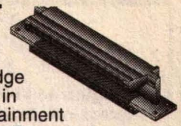
The Wet Look™



The Wet Look™ is a new generation of high gloss polymers formulated especially for the speaker industry. This superior coating provides a protective "coat of armor" for your paper cone speakers. A special U/V inhibitor has been added to reduce the decaying effects of the sun's ultraviolet rays. The Wet Look™ makes paper cones resistant to water, humidity, sun, and salt. Best of all, it's easy to apply and cleans up with soap and water. 1 pint can.

#EN-340-510 (Clear) ..... **8.95_{EACH}$**
#EN-340-512 (Black) ..... **8.95_{EACH}$**

72 Pin Game Cartridge Connector



Quality replacement for the game cartridge connector used in Nintendo Entertainment Systems (NES). Repeated loading and removal of game cartridges damages the connector contacts and produces symptoms such as a flashing blank screen or distorted picture. Revitalize your unit by replacing the game connector. It's simple; there is no soldering required and only a phillips head screwdriver is needed to complete installation in minutes! Our replacement connector has gold plated game contacts for long life, superior conductivity, and resistance to oxidation. One year warranty.

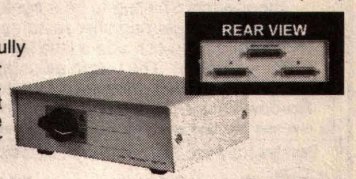
#EN-091-900 8.95_{(1-9)}$ 7.95_{(10-UP)}$

BigFoot™

"Copper tip" design standard 1/4" phone plug. Unsurpassed quality ensures low noise and high conductivity connection. All metal/nylon construction with external solder connections. Insulator sleeve included. 5/16" ID barrel. Made in the U.S.A.

#EN-092-200 (Mono) ..... **2.25_{(1-9)}$ 1.95_{(10-49)}$ 1.75_{(50-UP)}$**
#EN-092-206 (Stereo) ..... **3.25_{(1-6)}$ 2.90_{(10-49)}$ 2.65_{(50-UP)}$**

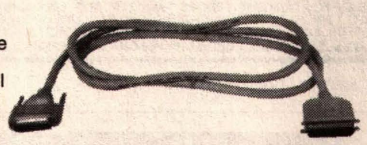
RS-232 A-B Switch



High reliability rotary type switch. Fully shielded, heavy gauge steel construction with gold plated connectors. All pins switched through (except ground). Used to switch multiple printers or computers. Full one year warranty. Net weight: 1-3/4 lbs.

#EN-130-010 ..... 9.95_{(1-2)}$ 8.95_{(3-9)}$ 7.95_{(10-UP)}$

Printer Cables

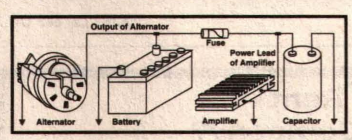


25 pin male RS-232 to 36 pin male Centronics connector. Fully shielded and molded cable with all 25 conductors connected. Convenient thumbscrew hardware on the RS-232 connector.

Part #	Length	Price (1-9)	Price (10-49)	Price (50-UP)
EN-130-220	6 ft.	$4.50	$3.90	$2.90
EN-130-225	10 ft.	5.50	4.95	3.75
EN-130-227	15 ft.	8.50	7.90	5.90
EN-130-228	25 ft.	10.90	9.50	7.90
EN-130-229	50 ft.	19.80	17.50	14.90

Car Stereo Power Supply Capacitors

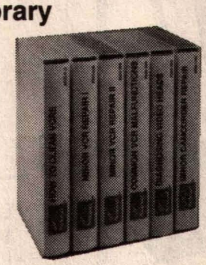
Most car amplifiers' power supplies simply lack the capability to produce large amounts of instantaneous power. These computer grade, car stereo capacitors work by storing energy and supplying, on demand, a quick burst of energy to the power amplifier. The result is tremendous bass punch and dramatically improved transient response. Feature gold plated terminals.



Part #	Value	Voltage	Dimensions	Weight	Price (1-15)	Price (16-UP)
EN-029-1000	1,000,000 uf	16 VDC	3"(dia.) x 8-1/2"	3 lbs.	$59.80	$52.80
EN-029-1005	1,000,000 uf	20 VDC	3"(dia.) x 8-1/2"	3 lbs.	79.80	73.50

Electronic Video Library

Video School videos make it easy for anyone to comprehend the complex operations of VCRs, camcorders, and more. From How to Clean VCRs for the video rental store, to Minor Camcorder Repair for the advanced service shop. There is something for everyone! These tapes also make great new employee orientation videos.

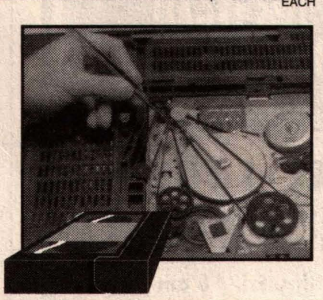


BUY THE SET AND SAVE!

Save over $25.00 by purchasing this complete library of six Video School instructional videos. You'll receive VCR 1-How To Clean VCRs, VCR 2-Minor VCR Repair I, VCR 3-Minor VCR Repair II, VCR 4-Common VCR Malfunctions, VCR 5-Diagnosing Video Heads, and Cam 1-Minor Camcorder Repair. Net weight: 5 lbs.

#EN-505-550 ..... 195.00_{EACH}$

Part #	Description	Price
EN-505-010	VCR 1, How To Clean VCRs	$28.95
EN-505-020	VCR 2, Minor VCR Repair I	38.95
EN-505-025	VCR 3, Minor VCR Repair II	38.95
EN-505-050	VCR 4, Common VCR Malfunctions	38.95
EN-505-035	VCR 5, Diagnosing Video Heads	38.95
EN-505-030	VCR Test Patterns Alignment Tape	23.95
EN-505-040	Cam 1, Minor Camcorder Repair	38.95
EN-505-085	Microwave Oven Repair	39.95
EN-505-080	Nintendo Repair and Maintenance	33.95
EN-505-090	IBM Compatible Computer Assembly	28.95
EN-505-095	Hi-Fi Alignment Test Tape	29.95



Skew Driver Pro

This unique tool features a gear driven offset bit driver to be used in tight spots or where conventional screwdrivers just won't fit. Includes 1/4" and 3/16" slotted bits, T15 Torx® bit, and 2 phillips bits that are contained in the handle compartment. Can also be used with a 1/4" electric drill. Made in the U.S.A. Net weight: 1/2 lb.

#EN-360-178 39.90_{(1-5)}$ 34.50_{(6-UP)}$

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CIRCLE 262 ON FREE INFORMATION CARD

8-COLOR LED
A RAINBOW OF LIGHT!
4 for $11.00

Imagine an LED capable of producing eight different colors, including near-white! Imagination becomes reality with this T 1-3/4 multi-color LED. Here's the technology: a red chip, a green chip, and two blue chips encased in a diffused T1-3/4 package. *Using various current combinations, you can produce red, orange, yellow, green, aqua, blue, violet or white light!* Detailed spec sheet included. What can you do with these (beyond the obvious amaze your friends!)? Create a single indicator system, designate various controls by color, make your project something out of the ordinary with multicolor LEDs!

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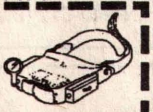
5 MW LASER MODULE $55.00

Mini 5 mW visible laser module wavelength 630 - 680 nm. 3/4" x 1/2"
complete unit has a built-in power supply and an adjustable culminating lens.
Operates on 3 volts DC
(a pair of AA or AAA batteries work great)
WARNING: AVOID DIRECT EYE CONTACT

PHOTON MICROLIGHT $10.00

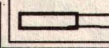
8 Candellas of bright red or yellow light, visible over a mile away! This super-bright LED is secured in a tough ABS case and runs on a 3V lithium battery (included!) It won't burn out because it is an LED! Specify red or yellow when ordering. Battery has a 5 year shelf life and lasts up to 11 hours. (replacement battery $0.98).Great for home or office use, popular with fire and rescue professionals, pyrotechnicians, stage performers, and more.

LIGHTED HEADSET MAGNIFIER $27.50



A great new item, this is a hands-free way to see little tiny parts as you work on them without having to be a contortion artist with a soldering iron! The headband style magnifier features bright side lights (4 AAA batteries not included) so you can add a little light to the area without clutching a flashlight under your chin! The velcro adjustable headband fits comfortably around your head, and the "goggles" pull down over your eyes for easy visibility. The visor has a built-in 1.8X lens plus a flip-down magnifier lens and a pull-down loupe for extra magnification power up to 4.8 times!

NEW Compaq Laptop Computer Nicad Rechargable Battery Pack



7.2 volts @ 120 mA. Many uses - power your projects for pennies!!! $4.95
approx. 3-1/2" x 1" x 3/8"

Passive Infra-red Talking Motion Detector !!! $27.50

"Stay out of that refrigerator !", "Watch your step!" ... The possibilities are mind-boggling with this talking motion detector. You speak into it to record your message (upto 12 seconds long), turn the unit on, and instantly your voice (or your mother-in-laws) reminds anyone in the vicinity that you were expecting them. Message can be changed with the flip of a switch. Uses 4 AA batteries (not included), or an external power source (built-in jack). May be used independantly (80 db output) or with an amplified speaker to blast your message throughout the house. Approx 4"x 3-1/2"x 1-1/2".

127 THERMOCOUPLES PELTIER JUNCTIONS

The peltier junction is a solid-state thermovoltaic device. Current applied to the device will produce heat on one side of the device and a cold surface on the other side. Water placed on the surface will freeze or boil depending on polarity of applied voltage. Ideal for applications from 3-12 VDC -- grab a battery and let your imagination run wild!
DOCUMENTATION INCLUDED!!!
Small $20.00(approx.1.17"x 1.17"sqx.12")
Large $29.50(approx. 1.56"x1.56"x.15")

VIDEO MONITOR
with built-in 2-way switcher $75.00

9" solid-state Black and White monitor has RCA connector for easy hook-up to your video camera. Built-in 2-way switcher enables you to use two cameras. These refurb units are great for security applicationslapproximately 8-1/2" x 8-1/2" x 9-3/8"
(*mailorder customers please include $15.00 for shipping & handling)

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CIRCLE 243 ON FREE INFORMATION CARD

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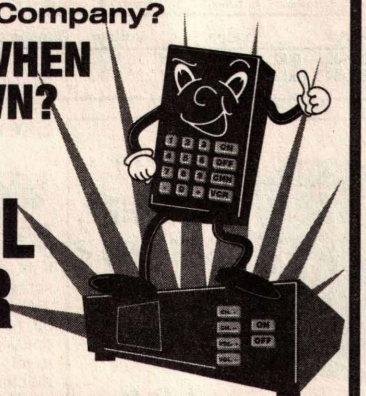
WHY RENT WHEN YOU CAN OWN?
TAKE CONTROL OF YOUR TV!!!



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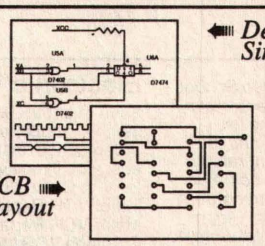

Design & Simulation

PCB Layout

- Easy to use schematic entry program (SuperCAD) for circuit diagrams, only $149. Includes netlisting, bill of materials, extensive parts libraries.
- Powerful, event-driven digital simulator (SuperSIM) allows you to check logic circuitry quickly before actually wiring it up. Works directly within the SuperCAD editor from a pulldown menu and displays results in "logic analyzer" display window. Starting at $149 this is the lowest cost simulator on the market. Library parts include TTL, and CMOS devices.
- Analog simulator (SuperSPICE) for $149. Allows AC, DC and transient circuit analysis. Includes models of transistors, discretes, and op amps.
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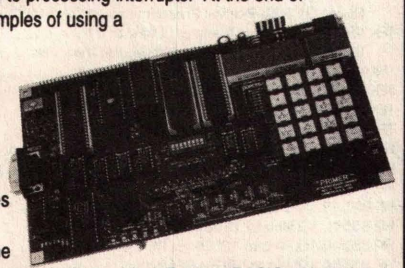

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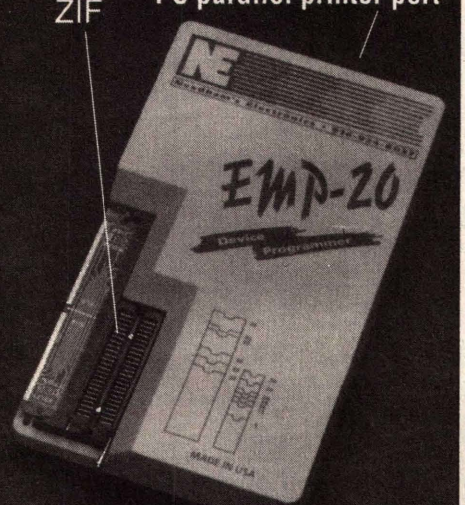

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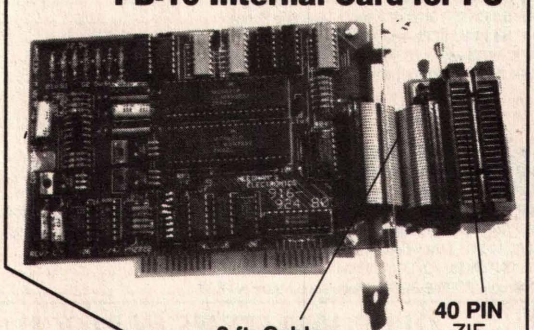

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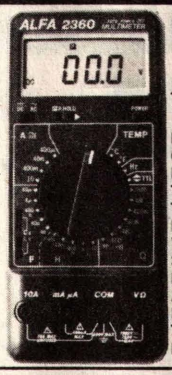

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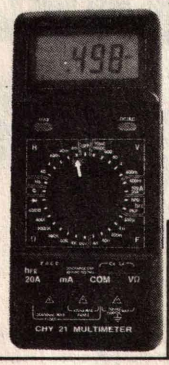

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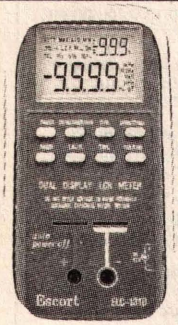

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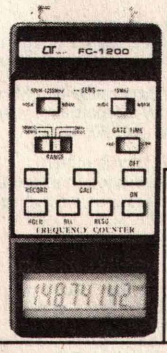

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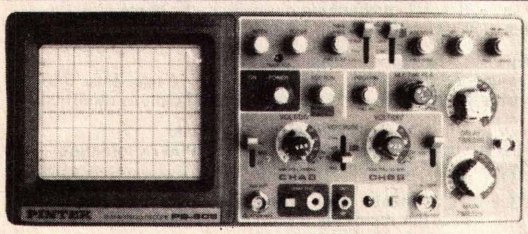

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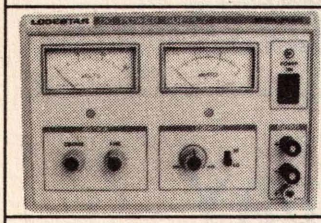

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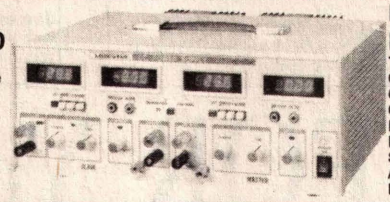
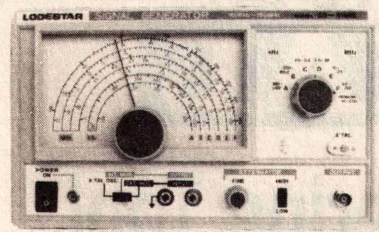
Short circuit and overload protected
PS-8200 with digital voltmeter $179.00
Also available: 30V/5A, 60V/3A, 60V/5A 16V/10A, 30V/10A



DC Power Supply Triple Output PS-8202 $499.95

Two 0-30 VDC , 0-3A outputs
One fixed 5VDC, 3A output
Capable of independent or tracking operation
Constant voltage and constant current mode
Four digital meters for volt and current display
Excellent regulation and low ripple
Short circuit and overload protected
Also available: 30V/5A triple output $549.95
Dual tracking 30V/3A, 30V/5A, 60V/3A, 60V/5A



RF SIGNAL GENERATOR SG-4160B $124.95

100 kHz-150MHz sinewave in 6 ranges
RF Output 100mVrms to 35 MHz
Internal 1kHz, External 50Hz-20kHz AM modulation
Audio output 1 kHz, 1 Vrms

RF SIGNAL GEN./COUNTER SG-4162 AD $229.95

Generates RF signal same as SG-4160B
6 digit frequency counter 1Hz - 150 MHz for internal and external source Sensitivity <50mV

AUDIO GENERATOR AG-2601A $124.95

10Hz - 1MHz in 5 ranges
Output: 0-8Vrms sinewave
0-10Vp-p squarewave
Synchronization: ±3% of oscillation frequency per Vrms
Output distortion:
0.05% 500Hz - 50kHz
0.5 % 50Hz - 500kHz
Output impedance: 600 ohm

AUDIO GEN./COUNTER AG-2603AD $229.95

Generates audio signal same as AG-2601A
6 digit frequency counter 1Hz-150MHz for internal and external sources Sensitivity <50mV

FUNCTION GENERATOR FG-2100A $169.95

0.2 Hz -2 MHz in 7 ranges
Sine, square, triangle, pulse and ramp
Output: 5mV-20Vp-p
1% distortion, DC offset ± 10V
VCF: 0-10V control frequency to 1000:1

FUNCTION GEN/ COUNTER FG-2102AD $229.95

Generates signal same as FG-2100A
Frequency counter 4 digits
Feature TTL and CMOS output

SWEEP FUNCTION GEN./COUNTER $329.95

0.5Hz to 5 MHz in 7 ranges
Sweep: Linear 10:1/Log 10:1 20ms to 2s
AM Modulation
Gated Burst, Voltage Control Generator
Generator Control Voltage & 6 digit counter
1Hz-10MHz for internal & external sources

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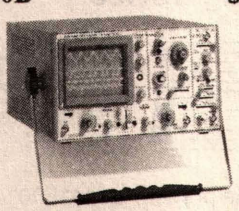
4 ch, 8 traces OS-6101 $1,499.95

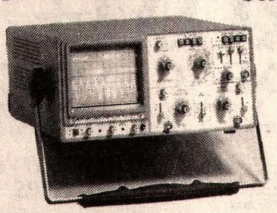
* 4 independent channels, 8 traces
* Time /Voltage cursor measurement
* ALT triggering function for 4 ch.
* Sweeps to 2ns/div, Delayed Sweep
* TV Sync., Ch. 1 output, Z-axis input
* 2 probes(x1, x10)

100 MHz Scope, 4ch. 8 traces
Best value all purpose scope
OS-6100B $1,329.95



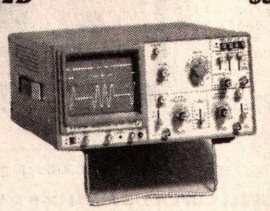
* 4 channels, 8 traces
* High sensitivity 500μV/div
* Sweeps to 2ns/div, Delayed sweep
* 20 kV accelerating voltage
* TV sync., Z-axis input
* A and B gate output
* Best price 100 MHz scope
* 2 probes(x1, x10)

50 MHz Triggering Oscilloscope
OS-653 $699.95



* Dual Channel
* Hold Off Function
* Delayed Sweep
* Built-in Delay Line
* TV Sync
* ALT Triggering
* High sensitivity 1 mV/div
* Trigger level lock function
* Z-axis input, CH1 output
* 2 probes(x1, x10)

20 MHz Oscilloscope
OS-622B $344.95



* Dual trace, X-Y operation
* TV Sync., Z-axis input,CH 1 output
* High sensitivity 1 mV/div
* Trigger level lock
* 2 probes (x1, x10)

OS-623B - 20 MHz w/Delayed Sweep.....$ 449.95
OS-935 - 5 MHz One channel.....$ 209.95

DC Linear Power Supplies
Single Output

* Constant voltage and constant current mode
* Voltage regulation ≤0.01%
* Current regulation ≤0.2%
* Low ripple and noise
* Overload and reverse polarity protection
* Features 2 analog or 1 digital meter(PS series)
  2 analog or 2 digital meters(PR series)

PS-1830 : (0-18V, 0-3A).....$209.95
PS-1830D : Digital Display.....$219.95
PS-1850 : (0-18V, 0-5A).....$219.95
PS-1850D : Digital Display.....$244.95
PS-3030 : (0-30V, 0-3A).....$224.95
PS-3030D : Digital display.....$254.95
PS-6010 : (0-60V, 0-1A).....$209.95

PR-1810H : (0-18V, 0-10A).....$349.95
PR-3060 : (0-30V, 0-6A).....$314.95
PR-6030 : (0-60V, 0-3A).....$314.95
PR-6030D : Digital Display.....$399.95

Triple Output DC Power Supplies

* Two variable 0-30VDC, 0-3A outputs
* One fixed 5VDC, 3A output
* Auto tracking
* Auto serial and parallel operation
* Constant voltage and constant current mode
* Continuous/dynamic load can be selected
* Features 4 analog or 2 digital displays

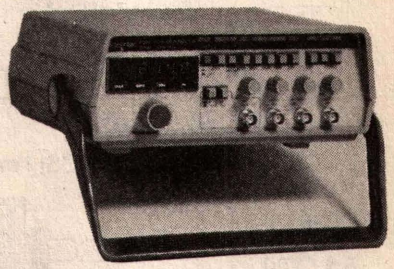
PC-3030 : (0-30V, 0-3Ax2).....$499.95
PC-3030D : Digital display.....$549.95

Programmable DC Power Supplies

* High stability , low drift, 4 digit display
* Front/rear output-sense switch selectable
* Auto step running w/timer settings
* 100 point programmability (PPS series)
* 50 point programmability (PPT series)
* Auto serial and parallel operation (PPT series)
* Auto tracking (PPT series), IEEE-488.2 and SCPI compatible command set (optional)

PPS-1860G: (0-18V, 0-6A).....$1099.95
PPS-3635G: (0-36V, 0-3.5A).....$1099.95
PPS-6020G: (0-60V, 0-2A).....$1099.95
PPT-1830G: (0-18V, 0-3Ax2, 0-6V, 0-5A).....$1399.95
PPT-3615G: (0-36V, 0-1.5Ax2, 0-6V, 0-3A).....$1399.95

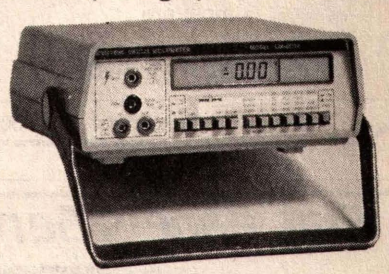
Digital Display Function Generator
FG-8016G $239.95



* Frequency Range: 0.02Hz to 2MHz
* Three Instruments in one: Function generator, Pulse generator & Frequency counter.
* Sine, Triangle, Square, TTL Pulse and CMOS output
* Built-in 6 digit counter with INT/EXT function
* 1000:1 tuning range
* Variable DC offset control

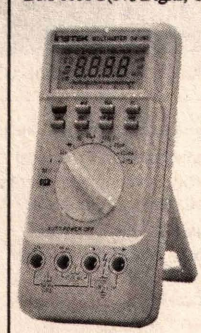
FG-8015 Function Generator
* 0.02Hz-2MHz (No Counter).....$189.95
FC-8131 Intelligent Counter 1.3GHz.....$469.95
FC-8270 Intelligent Counter 2.7GHz.....$629.95
UC-2010G Universal Counter.....$294.95

Digital Multimeter & C Meter
DM-8034(3½ digits) $179.95



* 8 Function, AC/DC voltage, AC/DC current, resistance
* Built-in C meter, diode test and audible continuity check
* High voltage 1000V and 20A range
* 0.5% basic accuracy

DM-8040 (3¾ Digits, True RMS)
* Measures ACV to 50 kHz.....$339.95
DM-8055 (5½ Digits).....$649.95
* 0.006% basic accuracy
* 1μV, 1mΩ, 1nA resolution
* dBm measurement
* Auto range, relative mode, Max/Min
DM-8055G(5½ Digits, GPIB).....$889.95



Model DM-392
(3¾ digits) $109.95

* Auto/Manual ranging(38 ranges)
* 42 Segment analog bar graph
* Data Hold/Min-Max memory /Relative mode
* Auto power off
* Overload protection
* Audible continuity check /diode test
* Capacitance: 1pF-40μF
* Frequency: 0.1Hz-1MHz
* 20 Amp range
* Double high energy fused (1A, 20A)
* 0.3% DCV accuracy

DM-351 : 3½ Digits w/Continuity, Auto Off.....$54.95
DM-352 : 3½ Digits, Cap. Freq. hFE, 20 Amp.....$79.95
DM-353 : 3½ Digits, Cap. Freq. Temp. hFE.....$84.95
DM-391 : 3¾ Digits, Auto, Cap. Freq. Min/Max....$99.95
DM-392 : 3¾ Digits, Hold, Min/Max 20Amp.....$109.95
DM-393 : 3¾ Digits, Peak, Logic, hFE, Freq.....$119.95

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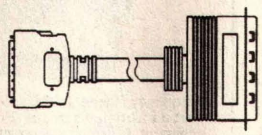

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Just ask for size and gender
most are
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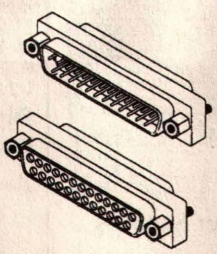
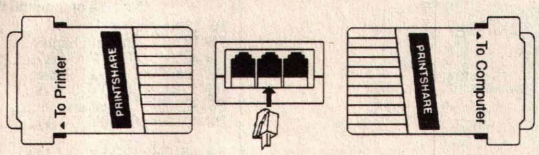


Printer Sharing Device



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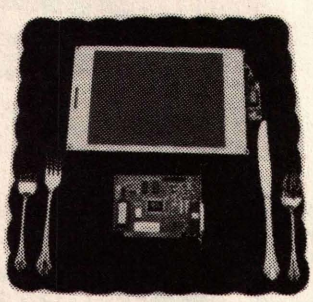

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2516,32,64,68764, **TMS2716**

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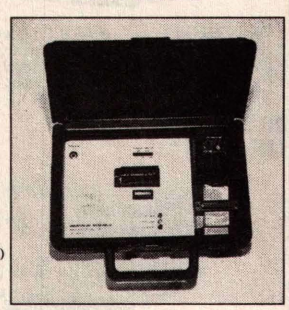

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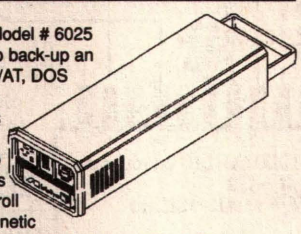
EXPERIMENTERS DELIGHT 20 MB TAPE BACK-UP SYSTEM



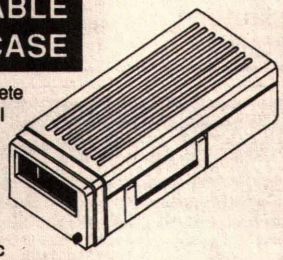
Interdyne Model # 6025 Designed to back-up an IBM PC/XT/AT, DOS 2.0 or later. These units were designed to do back-ups on a small roll of 1/4" magnetic tape. The units are 14.6" x 4.75" x 2.9" and weigh 10 lbs. The heavy-gauge metal chassis box contains a tape drive, power supply with fan and other components. Also includes IEC power cord, data cable and 2 rolls of back-up tape. Although these are new units, we do not wish to represent these as useable units.

CAT# TBS-2

We are selling them "AS-IS" for parts and experimentation.

$12.00 each

PORTABLE SCSI CASE



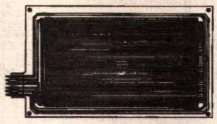
Nearly complete case for SCSI device. Includes 40 watt power supply (5 Vdc @ 3 amps, 12 Vdc @ 2 amps) with cooling fan, power switch, fuse holder, LED socket, power input receptacle, two standard 50 pin SCSI interface jacks, molex-type power connectors, interior cable with 50 pin socket connector and interior mounting rails. Front face plate is an aftermarket piece that doesn't quite go with the box but serves the purpose pretty well. Absent from the case is the switch in back which specifies the device's position in the chain. This can be easily bypassed with a few 0.1" shorting jumpers (our CAT# SJ-1). Also not included is a standard IEC power cord (our CAT# LCAC-60). Off-white case is 14.25" X 7.38" X 3.26" and has a folding handle for easy carrying.

$19.95 each

CAT# SCSI-1

2 for $36.00

FORCE SENSING RESISTANCE PAD

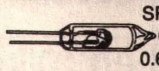


Interlink 7.5" x 11.5" x 0.03" thick plastic pad with two separate force sensing resistor circuits embedded in the pad. We have no factory specs or information on the intended application for the product. It was probably designed for some sort of touch sensitive apparatus. The resistance circuits read between 1.5 Meg and 0.5 Meg when nothing is touching the pad. The resistance decreases to as low as 1.5K ohms when pressure is applied to the pad and appears to be dependent upon force and the amount of surface area acted upon. An interesting device for experimentation.

$4.50 each

CAT# FSR-1

MERCURY TILT SWITCH

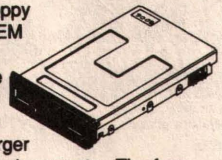


SPST mercury tilt switch. Glass bulb is 0.25 "dia. X 0.67" long. Circuit is closed in vertical position. Rated 750 ma.

$1.00 each

CAT# MS-15

720K 3.5" INTERNAL FLOPPY DRIVE



Sony # MP-F11W-2Z Brand new 720 KB floppy drives. Built for an OEM product, these are, in every way, compatible with PC/XT/AT computers except that the faceplate is slightly larger than those on exact replacements. The faceplate size on these is 4.04" X 1.23". (Normal size is 4" X 1"). The faceplate is removable and can be trimmed if desired. In some cases it may work without trimming. Also, we have found that, when used in 5.25" bays with the adapter kit below, the adapter can easily be modified to accommodate the unit. Because of this slight inconvenience, we are selling these drives at an incredibly low price.

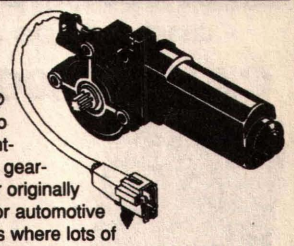
$14.00 each

CAT# MPF-11SF

10 for $120.00

INSTALLATION KIT for MPF-11SF allows for installation into 5.25" drive bays. Simply cut and remove three plastic gussets to install. **CAT# FDD-3.5** $3.50 each

12 Vdc GEAR MOTOR



Denso Brand 40 RPM @ 12.6 Vdc @ 600 ma. (no load). Right-angle drive gear-head motor originally designed for automotive applications where lots of torque is required. 6.68" long X 3.5" X 1.62" thick. Three mounting holes on 1.9" and 2.6" centers.

$17.50 each

CAT# DCM-64

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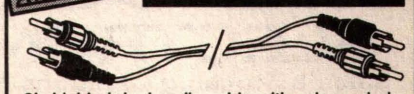
9 FOOT DUAL AUDIO CABLE



9' shielded dual audio cable with color coded (red and yellow) RCA style pin plugs either end. Black cable.

$1.00 each

CAT# DCB-108

10 for $8.50 • 100 for $75.00
1000 for $500.00

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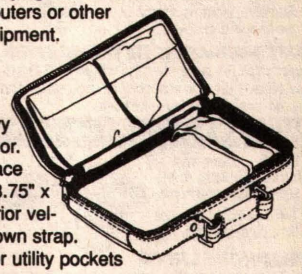

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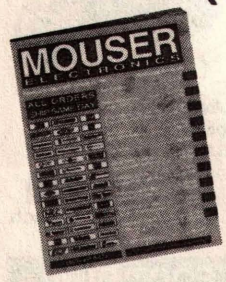

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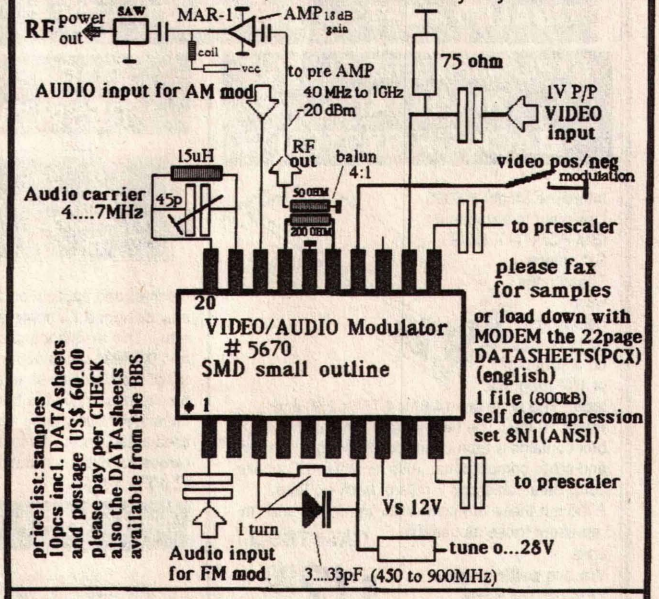

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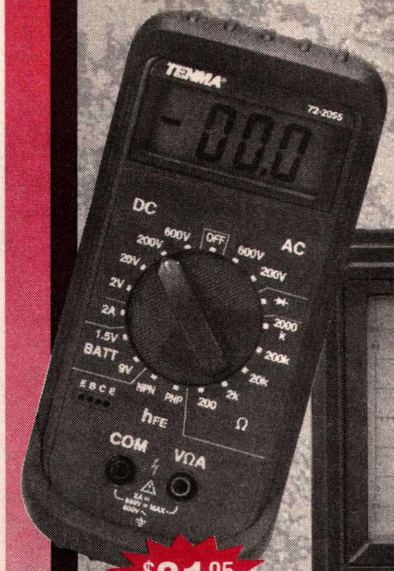

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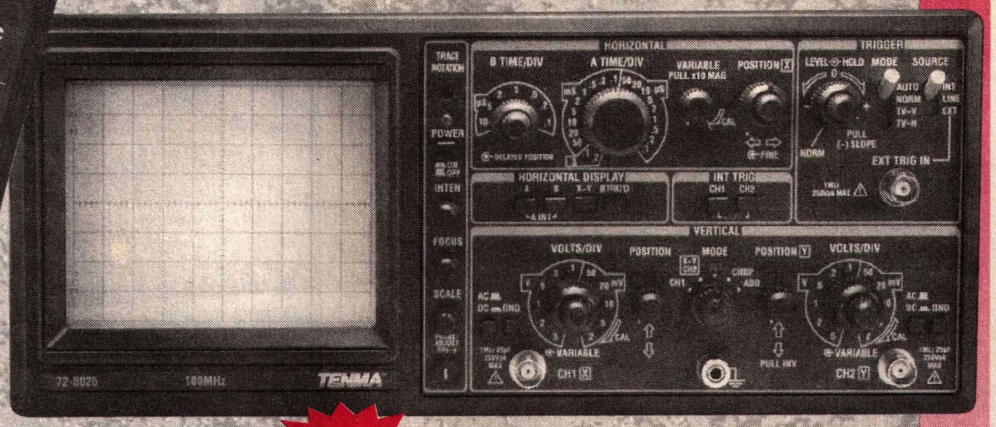

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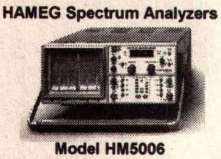

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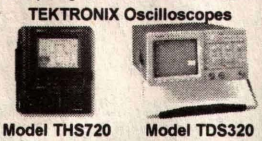

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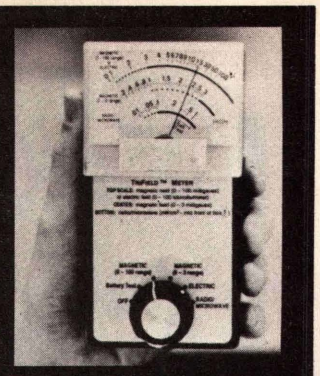

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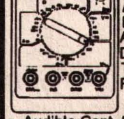

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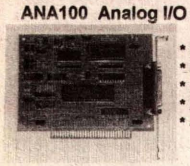

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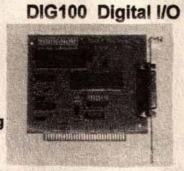

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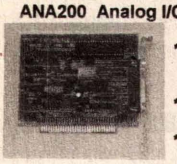

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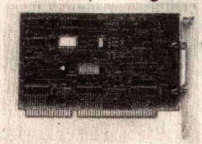

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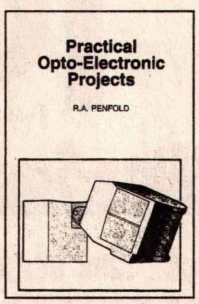

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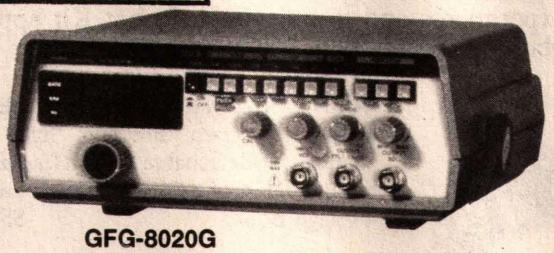

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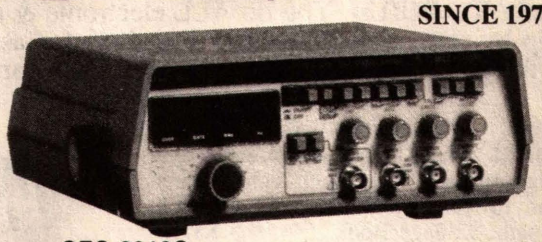

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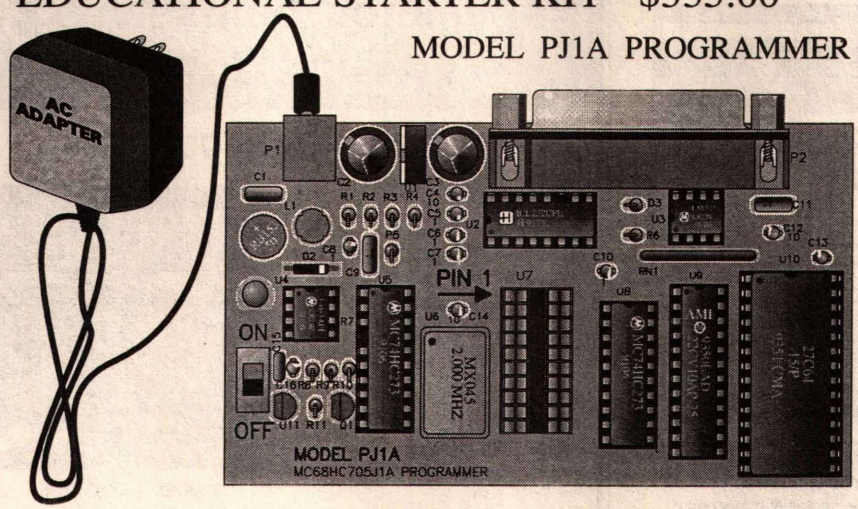

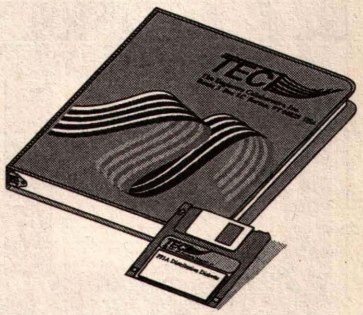

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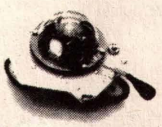

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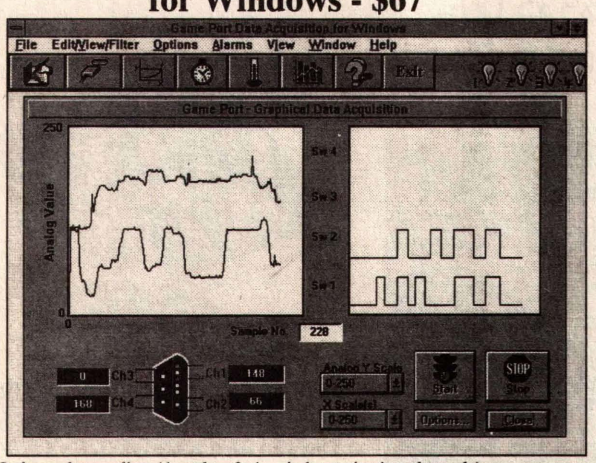

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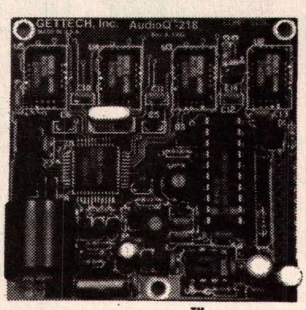

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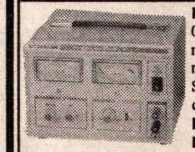

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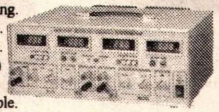

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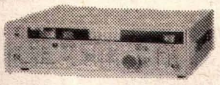

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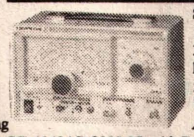

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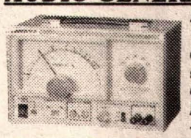

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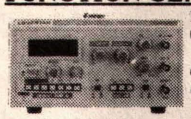

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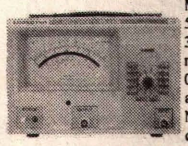

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OS-7305B $249.00 DC~7MHz, *Vertical*: 10mV/Div; Horizontal: 250mV/Div; 10Hz~100KHz in 4 ranges; 3" CRT;Internal and External Sync.; Input: 1MΩ/35pF. **OS-7010A $369.00** DC~10MHz. 5" CRT, 10mV/Cm~10V/Cm, 1MΩ. **OS-622B $344.95** 20MHz/dual trace **OS-653 $699.95** 50MHz, dual, delay sweep, ALT trigger, TV syn. **OS-6100B $1329.95** 100MHz, 4ch. 8 traces, delay sweep,best buy

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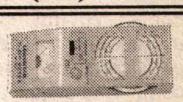

DM-4061 $89.95 1.5-250MHz, 6 bands;6 plug-in coils, 2 transistor, and 1 diode. *Modulation*: ≈ 2KHz Sinewave. *Crystal Oscillator*: 1-15MHz. Wave absortion meter. Using 9VDCpower supply.

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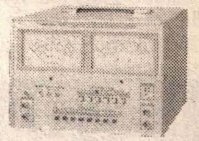

DM-3104A $799.95 *MEASUREMENT:* *Range*: 0.01%-30%, 0.1/0.3/1/3/10/30% full scale. *Freq.*: 400Hz±10%, 1000Hz±10%(HPF). *Input*: 3mV-100V, ratio measuring 20dB. *Auto. Switching Ranges*: Fundamental Freq. = (fo)±10%; *Fund. Rejection*: >-80dB at (fo)±5%; >-70dB at (fo)±10%. *Harmonic Accuracy*: ±0.5dB, 1.8(fo)-20KHz. **DM-3204 $1,599.00** dual channels.

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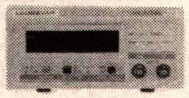

FC-5250C $119.95 *Freq. Range*: 10Hz-220MHz: (HF)10Hz-20MHz, (VHF)10MHz-200MHz *Gate Time*: 0.1 & 1sec. *Max. Input*: 10Vp-p. *Input Sensitivity*: 35mV 10Hz-200MHz. *Display*: 7-digit LEDs. *Input Imped.*: (HF) 1MOhm, (VHF) 50Ohm.

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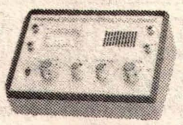
SIGNAL TRACER/INJECTOR



SE-6100 $134.95 **TRACER:** Gain Max. 60dB *Attenuation*: 0/20/40/60dB *Input Imped.*: 100KOhm *Output Imped.*: 600Ohm; *Speaker*: 8 Ohm. **INJECTOR:** *Freq.*: 1KHz Squarewave; *Output Level*: Continuously variable 0 - 4.5Vp-p.

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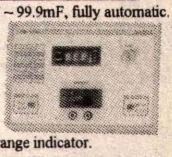

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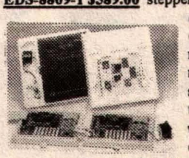

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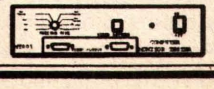

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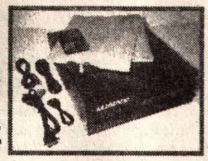

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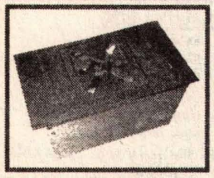

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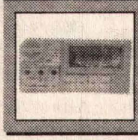

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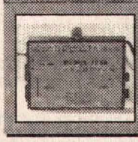

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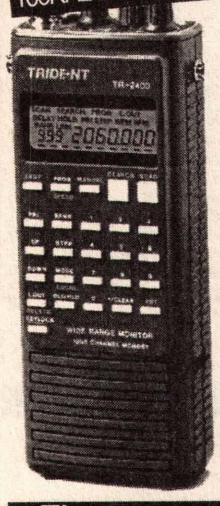

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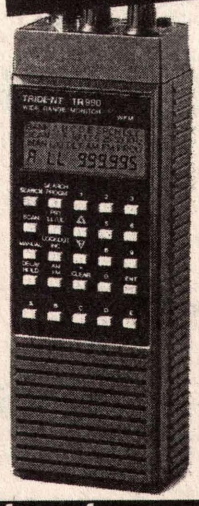

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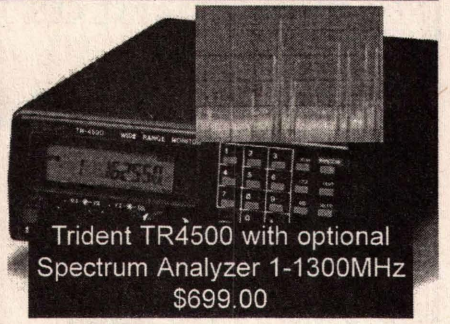

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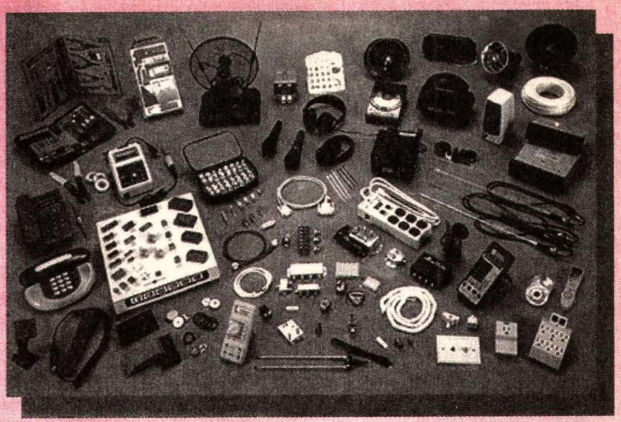

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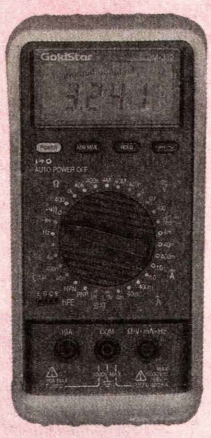

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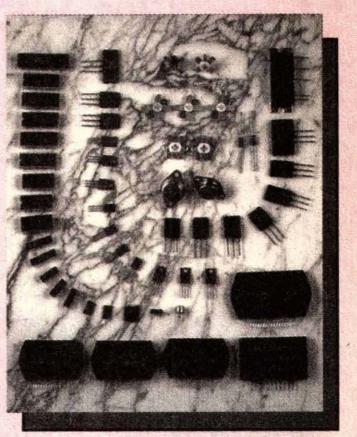

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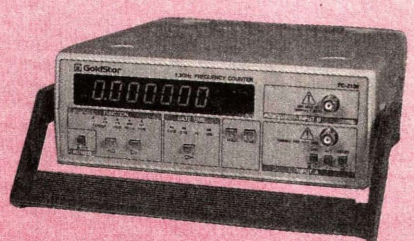

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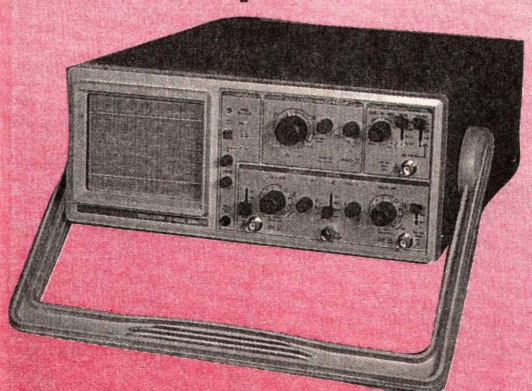

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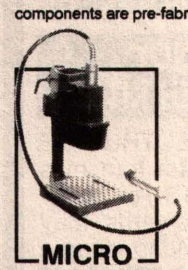

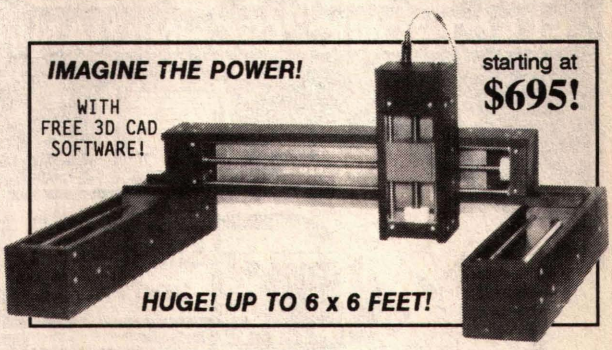

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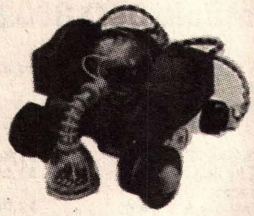

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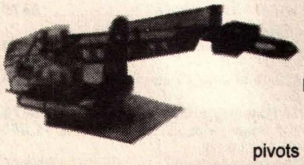

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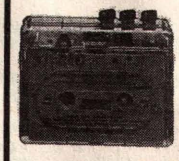

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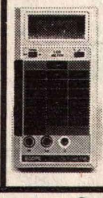

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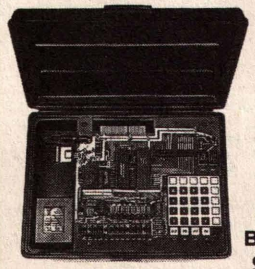

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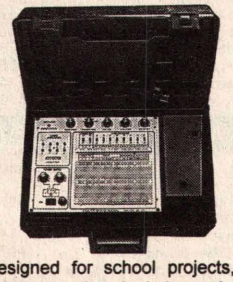
From scratch you build a complete system. Our Micro-Master trainer teaches you to write into RAMs, ROMs and run a 8085 microprocessor, which uses similar machine language as IBM PC.

Digital/Analog Trainer
Complete Mini-Lab For Building, Testing, Prototyping Analog and Digital



By Elenco in U.S.A.
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$159.95
Kit
XK-525K
$129.95
Designed for school projects, with 5 built-in power supplies. Includes a function generator with continuously variable, sine, triangular, square wave forms. All power supplies are regulated and protected against shorts.

AM/FM Transistor Radio Kit
with Training Course
Model AM/FM 108
$29.95
14 Transistor, 5 Diodes
Easy to build because schematic is printed on the PCB
Makes a great school project
Model AM-550 AM Only $17.95

Telephone Line Analyzer

Kit TT-400K $19.95
Assembled TT-400 $26.95

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QUALITY - ELENCO OSCILLOSCOPES

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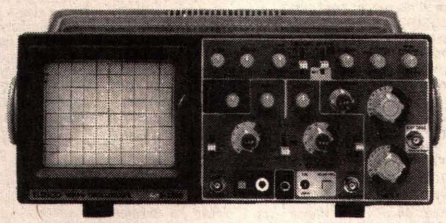


60MHz

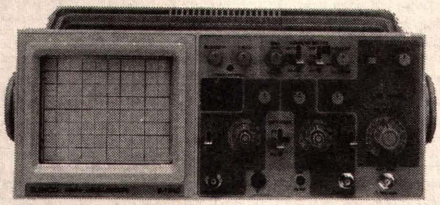
S-1360 $775

Delayed Sweep

S-1365 $849

Cursor Readout

- Voltage, Time
- Frequency differences displayed on CRT



40MHz

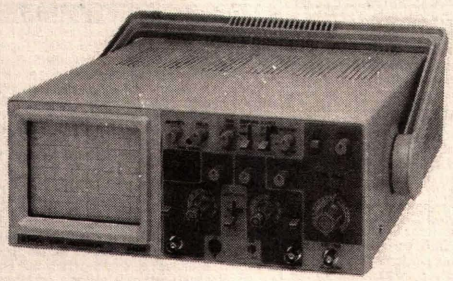
S-1340 $495

2- Channel

S-1345 $575

Delayed Sweep

- Beam Find
- Component Tester



25MHz

S-1325 $325

2- Channel

S-1330 $449

Delayed Sweep

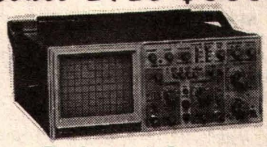
- Beam Find
- Component Tester

Dependable Equipment at Affordable Prices

B+K 20MHz

2 Channel

Model 2120 $389.00



Delayed Sweep

Model 2125 $539.95

40MHz DUAL -TRACE

Model 1541B

$749.95

- 1mV/div sensitivity
- Video sync separators
- Z axis input
- Single sweep
- V mode-displays 2 signals unrelated in frequency

60MHz DUAL-TRACE

Model 2160

$949.95

- 1mV/div sensitivity
- Sweep to 5ns/div
- Dual time base
- Signal delay line
- Component tester
- V mode-displays 2 signals unrelated in frequency

100MHz THREE-TRACE

Model 2190

$1,379.95

- 1mV/div sensitivity
- Sweeps to 2ns/div
- Dual time base
- Signal delay line
- 19kV accelaerating voltage
- Calibrated delay time multiplier

20MHz ANALOG with DIGITAL STORAGE

Model 2522A

$869.95

- 20MHz analog bandwidth
- 20MS/s sampling rate
- 2k memory per channel
- 20MHz equivalent time sampling

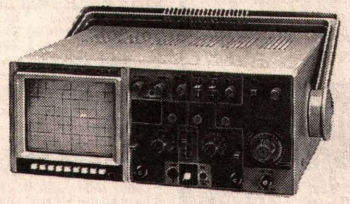
HITACHI POPULAR SERIES

V-212 - 20MHz, 2 Channel	$449.00
V-222 - 20MHz, DC Offset	$695.00
V-422 - 40MHz, Dual Trace	$849.00
V-522 - 50MHz, Dual Trace	$975.00
V-523 - 50MHz, Delayed Sweep	$995.00
V-525 - 50MHz, w/ Cursor	$1,069.00

HITACHI COMPACT SERIES SCOPES

V-660 - 60MHz, Dual Trace	$1,375.00
V-665A - 60MHz, DT, w/cursor	$1,449.00
V-1060 - 100MHz, Dual Trace	$1,549.00
V-1065A - 100MHz, DT, w/cursor	$1,695.00
V-1085 - 100MHz, QT, w/cursor	$2,125.00
VC-6045A - 100MHz, Digital Stor	CALL
VC-6025A - 50MHz, Digital Stor	CALL

Elenco DS-203 20MHz, 10MS/s Digital Storage Oscilloscope

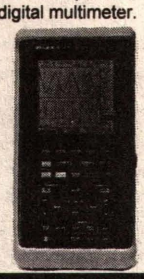


$749

2K Word Per Channel • Plotter Output 8 Bit Vert. Resolution • 2048 Pts Hor. Resolution • Much More.....

FLUKE SCOPEMETERS

A handheld instrument that combines a 50MHz, 25MS/s dual channel digital storage oscilloscope with feature-packed 3000 count digital multimeter.



Model 93 - $1,225
Model 95 - $1,549
Model 97 - $1,795

- Autoset, automatically sets voltage, time & trigger
- Multimeter display; 3-2/3 digits (>3000 counts)
- True RMS volts; AC or AC+DC up to 600V

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NIGHT VIEWERS

FIBER OPTIC TUBES Used 1st gen. 25 or 40mm (input/output window dia). With a suitable 'fast' lens give a good image in half moon light. Can be IR assisted to see in total darkness. Each tube is supplied with an 9V - EHT power supply kit:
25mm tube **$90**, 40mm tube **$120**
We also have blemished versions of these tubes (not in central viewing area). Satisfaction guaranteed! Both sizes (please specify) & EHT kit **$35**

INTENSIFIED NIGHT VIEWER KIT See in the dark! Make your own night scope that will produce good vision in sub-starlight illumination! We supply a three stage fiber optically coupled image intensifier tube *and* an EHT power supply kit, lens and eyepiece. 25mm **$270**, 40mm **$360**

SMALL PASSIVE NIGHT VIEWER KIT Supplied with new and completely assembled USSR made scope. The EHT power supply is supplied in kit form. Will work in extremely low light levels! Best value small night vision scope available: **$220**
Tube only from the above and an EHT power supply kit: **$90**

IR TUBE AND SUPPLY A tube and supply combination that can be used as the basis of making a very sensitive IR responsive viewer. Typical sensitivity 0.01 lux. Tube and supply kit **$80**

CCD CAMERA-VCR SECURITY SYSTEM

Ready made PIR detector module and learning remote control combination can trigger any domestic IR remote controlled VCR to *RECORD* human activity within a 6m range with an 180º view. Starts VCR recording at first movement and ceases recording a few minutes after the last movement has stopped. Just like commercial CCD-video recording systems costing $1000's!! No connection needed to your existing VCR. IR detector module, control kit, IR learning remote control and instructions **$70**

TINY PCB CCD CAMERA Mono, with auto iris lens, 0.1 lux, IR responsive, can be used in total darkness. 1.8 x 3.75 x 1 inch, weight 1.4 oz. Can be connected to video-in of a standard monitor or VCR. **$99**

LOW COST IR ILLUMINATOR KIT Use with CCD camera. Has 42 880nm/30mW LEDs. Variable power output, 10-15V DC operation. **$30**

LASERS

HELIUM-NEON 633nm red laser tubes from new and near new equipment. Output power in the range of 2.5 to 7.5mW. Includes our 12V Universal Laser power supply. *Warning: High voltage at dangerous energy levell* 2.5-4mW tube & supply **$50** 4-7.5mW tube & supply **$80**

VISIBLE LASER DIODE KIT 5mW 670nm visible laser diode and collimating lens, housing and driver kit. Easy to build, very small **$26**

GEIGER COUNTER

Ready made Geiger counter detects dangerous Beta and Gamma rays. Two-modes: accumulates counts or terminates count after 1 minute. Alarm sounds if radiation exceeds a safe level, LCD display, 9V battery operation (15mW!). **$74**

KITS and BITS

2-CHANNEL UHF REMOTE CONTROL KIT 1 Tx and 1 Rx **$31**, extra Tx: **$12**
4-CHANNEL UHF REMOTE CONTROL KIT Two Tx and one Rx: **$68**
LASER BEAM COMMUNICATOR KIT: Tx, Rx, plus IR laser: **$39**
PLASMA BALL KIT: PCB and components, needs a light bulb: **$18**
SLAVE FLASH TRIGGER: Triggers a second flash unit by picking up light from camera mounted flash: **$5.50**
SOUND TRIGGERED FLASH: Triggers flash from sound picked up by a microphone, adjustable: **$10**
PC DRIVEN ELECTROCARDIOGRAM: Silk screened/solder masked PCB only and 3.5" disk with instructions. Uses common components: **$8**
FM TRANSMITTER KIT-MKII: $8
HIGH POWER IR LEDs 880nm 12º 30mW @ 100mA **10 for $6**
INFRARED FILTER Very high quality IR filter and plastic lens cover. Fits over most torches incl MAGLITEs, for a good source of IR. Use with passive and active viewers. **$11**

VEHICLE COMPUTER

Solar/battery powered bicycle-vehicle computer. Programmable wheel dia, so can be used on any wheel! Weather and shock resistant, speedometer, average & maximum speed, tripmeter, odometer, auto trip timer, scan, freeze frame memory, clock, pick-up sensor/magnet and mounting hardware supplied.**$25**

TINY FM TRANSMITTER

Tiny ready-made self-contained FM transmitter in a small black metal case. Powered by single 1.5V silver oxide LR44/G13 battery with inbuilt mic. Tuning range 88-108MHz, battery life 60 hours, weight 15g, Dimensions: 1.3" x 0.9" x 0.4". **$27**

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Add $5 total S/H (US, Canada). All items in stock. **VISA, MCard** OK. No CODs or "bill me"s. **New Catalog** (200+ offers) $2 w/order, $5 w/o (check or MO). NO dealers. Since 1971. As seen on **CBS "60 Minutes," Forbes,** etc. By **John Williams** - former Lockheed Senior Engineer, NMSU CS Professor, DOD Electronic Weapons Engineer, NIH Health Physicist.
Wanted: 5 MAC IIfx, PC486 (or better), peripherals, new surplus electronic parts, test equipment - buy, trade.
***All software supports all IBM-PC compatible x86 systems (8086 - Pentium)**

Off-The-Shelf HARDWARE
Van Eck Systems ◆ Data Card Reader/Writers ◆ ATM3 ◆ RF/EM/µWave/Radar/Ultrasonic/IR/Light/Sound Detectors/Receivers/Xmitters/Jammers/Blasters ◆ Security/Surveillance ◆ EM Lab/Weaponry/Countermeasures ◆ Neurophone/Rife/Hieronymus/Resonant Crystal Radionics ◆ Voice Disguisers ◆ ESS Infinity Devices ◆ Phone Color Boxes ◆ DTMF Decoders ◆ Lineman's Handsets ◆ Bug/Tap Detector/Blaster ◆ Bumper Beeper/Child Finder ◆ Panic Button ◆ Carjack/Kidnap Foiler ◆ Hidden Presence Detectors ◆ Hearing Assistor ◆ Shriek Module ◆ TENS ◆ Subliminal Mixer/Amp ◆ Vortex Generator ◆ 6th Sense Communicator ◆ Noise Cancel. System ◆ Electronic Dowser ◆ Laser ◆ Levitator - more! See our **New Catalog!**

SPECIAL PROJECTS
We design/build/obtain/repair/modify/maintain/consult on any device/system/process/project - electronic/computer/mechanical/optical (ex: phone/auto/security/radionic/lab/energy/HV/EM/RF/Radar/ultrasonic/IR/UV/commo/consumer) for business/personal/invention needs. Describe & include $30 pre-engineering fee (no obligation). Time & cost estimates 7-10 days. Confidentiality guaranteed.

CELLPHONE MODS
See our Catalog for our infamous cellphone modification guide ($69) - detailed, comprehensive, covers all makes - 10 times more info than competitor's "guide"). (Do **Special Projects** (above) to get up-to-date hardware/software).

VOICE MAIL HACKING
How **Voice Mail Box (VMB)** systems are used and the specific ways they are hacked. Includes **ASPEN, MESSAGE CENTER, BIX, GENESIS, EZ, SYDNEY, PHONE MAIL, AUDIX, CINDY, CENTAGRAM, SPERRY LINK, RSVP,** etc. Absolutely required for all users, sysops and security personnel! **$29.**

PBX HACKING
1,000s of PBXs are hacked to the tune of $ Billions/yr! While **"VOICE MAIL HACKING"** details how VMSs are hacked for "phun" and profit - including VMS methods for hacking PBXs themselves - **"PBX HACKING"** addresses ALL issues relating to PBX hacking, including countermeasures! Can your business or agency afford a $90,000 phone fraud loss (the average loss due to hacked PBXs)? As described in **Forbes Magazine. $29**

PHREAKING CALLER ID & ANI
Details on how they work and dozens of effective ways of defeating **Caller ID, ANI, *69, *57,** and **Call Blocking** and **"67". Also describes Caller ID, Orange, Beige, Cheese** and **CF Boxes, ESS, SS7, E-911,** various **CLASS services, CNA, NON PUB DA, CAMA, DNR, 800-ECR, Diverters, Extenders, Centrex** - more. **$29.**

Beyond PHONE COLOR BOXES
Dozens phone color boxes described - many circuits. Plus **Call Forwarding, Conferencing, Phreak History, Glossary, Diverters, Extenders, Loops, REMOBS, Bridging Heads & Cans, Optocom, 3rd Party** and many other non-box methods - more. **$39.**

ROBOFONE AUTODIALER
Powerful, versatile, menu-driven **"Wargames"** autodialer lets you dial any quantity (up to 10K) or mix of local/long distance numbers in any order, over any length of time, whether busy or answered (your choice) and log the times, commands and results to monitor, printer and/or disk. Quick-dial directory of up to 600 numbers. BUSY redial options. Direct modem command and control. All Result Codes, including VOICE and RINGING. Optional shell to terminal program upon CONNECT. Exit to menu or DOS (for batching). **Manual + Disk* $29.**

By an ORDER of the MAGNITUDE
The most comprehensive, hard-hitting, hi-tech survival book ever written! Topics include electronics, computers, energy, weapons, concealment, revenge, alarms, etc to survive today's dangerous world. We all face increasingly financially and physically brutal times! Field-expedient use of technology in various threat and conflict environments and scenarios. **$49.**
Sold for educational purposes only

COMPUTER PHREAKING
Describes in detail how computers penetrate each other, and how **VIRUSES, TROJAN HORSES, WORMS,** etc are implemented. Dozens of computer crime and abuse methods and countermeasures. Includes disk filled with hacker text files and utilities, and the legendary **FLUSHOT+** protection system **(Ed. Choice, PC Magazine).** BBS advice, password defeats, glossary - much more! **Manual + Disks* $39.**

The HACKER FILES
Compilation of 100s of the best articles written (in ASCII) by top hackers & phreakers. Covers every major topic in hackerdom! **3 HD Disks* $59.**

Beyond VAN ECK PHREAKING
Eavesdropping on TV and computer video signals using an ordinary TV described in detail. Includes security industry reports. Range up to 1 KM. Plans include both the **Consumertronics** and the original **Top Secret Van Eck designs! $29.**

STOPPING POWER METERS
As reported on **CBS "60 Minutes": How certain devices can slow down - even stop - watthour meters - while loads draw full power!** Device simply plugs into one outlet and normal loads into other outlets. Also describes meter creep, overload droop, etc. Plans **$29.**
I.Q. MANUAL: External magnetic ways (applied to the meter itself) to slow down and stop watthour meters while drawing full loads. Plans. **$19. KW-HR METERS:** How watthour meters work, calibration, error modes (many), ANSI Standards, etc. **Demand** and **Polyphase Meters.** Experimental results to slow and stop meters by others. **$19.** Any 2, **$36.** All 3, **$59.**

AUTOMATIC TELLER MACHINES
ATM crimes, abuses, vulnerabilities and defeats exposed! 100+ methods detailed, include: Physical, Reg. E, cipher, PIN compromise, card counterfeiting, magnetic stripe, false front, TEMPEST, Van Eck, tapping, spoofing, inside job, super-cool, vibration, pulse, high voltage - others. Case histories, law, countermeasures, detailed security checklist, labeled internal photos, figures. ATMs contain up to $250,000 in cash! Recent $350,000 ATM crime spree still unsolved! **$39.**

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Cardholders, merchants, banks suffer $ Billions in losses annually because of credit card fraud. Describes every known means of credit card fraud and scams. **Protect yourself! $29.**

CONS, SCAMS & SWINDLES
Cons & scams and related swindles fleece Americans of $100+ Billion per year! The most comprehensive survival manual on cons & scams of all kinds - from the classic to hi-tech. Details on 100s and many variations. And countermeasures. **Protect yourself! $39.**

STEALTH TECHNOLOGY
Police radar is fascinating! It also has error rates of 10-20%! Every known error mode - stealth method and material used to minimize radar reflections - tactic and strategy to fight unjust radar tickets (that cost you $100s in insurance and risk cancellation) - methods to detect and jam signals - fully described! **$29.**

SECRET & SURVIVAL RADIO
Optimum survival and security radio equipment, methods, freq allocations and voice/data scrambling/encoding. Includes small receivers/transmitters, telemetry, antenna optimizations, remote monitoring and control, security, surveillance, and ultrasonic, fiber-optic and infrared commo. 70+ circuit plans, tables. **$29.**

HIGH VOLTAGE DEVICES
HV devices plans: **Stun Gun, Taser, Prod, Cane, Blaster, Flasher, Zapper, Audio/RF/Radar Jammer, Fence Charger, Plasma & Van de Graaff Gens., Jacob's Ladder, Geiger Counter, Ozone Gen., Fish Stunner, Plant Stim., Kirlian,** more! All plans for only **$29.**

UNDER ATTACK!
Electromagnetic Interference and **Electronic Weapon Attacks** cause: Cancer, birth defects, and profound psychological, neurological, cardiovascular and immune system disorders! Destructive to people, animals, plants, equipment! Includes **ACTUAL CASES OF EM ATTACKS** (we investigated)! Includes how to verify and pinpoint EMI and electronic attack sources, and effective countermeasures. **$29. EM BRAINBLASTER:** Tutorial and plans for powerful **ELECTROMAGNETIC WEAPONS** and **LAB DEVICES.** Optimum circuits, freqs, waveforms, duty cycles, intensities. Thorough. **$29.** Both **$49.**

RADIONICS MANUAL
Exciting electrical, electronic, electromagnetic therapeutic, diagnostic & preventive devices (mostly experimental). History, descriptions, plans (dozens), availabilities of **Radionics Devices** from early to modern. While drugs cost $100s, electricity costs pennies! **$29. HEAL THYSELF:** Plans for 3 major electronic therapeutic devices of types approved by **FDA. $19.** Both **$39.**

CRYPTANALYSIS TECHNIQUES
Five powerful menu-driven crypto programs (in .COM and .BAS source code) to analyze, decrypt "secure" ciphertexts. Worked-out examples. Recommended by prestigious **"Computers & Security." Manual+Disk* $29.**

ROCKET'S RED GLARE
How to design and build solid-propellant amateur and survival rockets. Emphasis on formulation, manufacture, installation of propellants, motors, Igniters, etc. Includes list of commonly available materials, and the design of launch pads and test beds and their electronics. **$29.**
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Underpaid, overworked, harassed or abused? Victim of office politics? Stuck in a dead-end job? Can't find a good job? Expect to be laid off, fired or transferred soon? The ultimate no-holds-barred, looking-after-#1 Machiavellian techniques to find, obtain, optimize and keep top jobs, pay and benefits. **The Rules of the Game for a Game without Rules!** From resume to CEO. **$29.**

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Check Out These Deals From CIRCUIT SPECIALISTS!

Ball Bearing 12V DC Fans

csd-4010

csd-6025

csd-8025

csd-9225

csd-1225

These High Quality Fans feature Ball Bearings and Brushless DC Motors. All of them are designed to meet UL, CSA & VDE Standards. Design these fans into power supplies, computers or other equipment requiring additional air flows for heat removal. These fans are regular Circuit Specialists stock items — they are not surplus.

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CAT NO	PRICE EACH 1	10	25	100
CSD 4010-12	$ 9.88	$ 6.38	$5.48	$4.87
CSD 6025-12	9.38	5.91	5.41	4.71
CSD 8025-12	8.88	5.85	5.19	4.49
CSD 9225-12	8.95	6.14	5.29	4.59
CSD 1225-12	11.45	8.96	7.82	6.85

Specifications

CAT NO	DIMENSIONS (MM)	RATED VOLTAGE (V)	START VOLTAGE (V)	INPUT CURRENT (A)	AIR FLOW (CFM)	STATIC PRESSURE (INCH-H_2O)	SPEED (RPM)	NOISE LEVEL (dB)	WEIGHT (g)
CSD 4010-12	40x40x10mm	12	7	0.06	5.1	0.19	5,500	26	20
CSD 6025-12	60x60x25mm	12	5	0.13	13.7	0.165	4,500	28	65
CSD 8025-12	80x80x25mm	12	5	0.16	37.8	0.177	3,000	31	80
CSD 9225-12	92x92x25mm	12	5	0.32	42	0.18	2,800	37	95
CSD 1225-12	120x120x25mm	12	5	0.35	62	0.180	2,500	42	135

Ball Bearing AC Fans

csa-8038AC

Size: 80 x 80 x 38.5mm (3.15 x 3.15 x 1.5")
Weight: 370±10gm (0.82lb.)
Frame/Housing: Aluminum
Impeller: Glass reinforced thermoplastic UL94V-O
Bearing Type: Ball Bearing
Dielectric Strength: 1 minute at 1,500VAC/50-60Hz
Operating Temp: -20°~+85°C
Life Expectancy: 50,000 Hrs (at 25°C, 65%RH)
Motor Protection: Impedance Protected
Safety Approvals: Meets UL, CSA, VDE Standards

CAT NO	PRICE EACH 1	10	25	100
CSA8038AC	$15.26	$12.92	$10.98	$9.73

csa-1225AC

Size: 120 x 120 x 25.5mm (4.71 x 4.71 x 1.00")
Weight: 390±10gm (0.86lb.)
Frame/Housing: Aluminum
Impeller: Glass reinforced thermoplastic UL94V-O
Bearing Type: Ball Bearing
Dielectric Strength: 1 minute at 1,500VAC/50-60Hz
Operating Temp: -20°~+85°C
Life Expectancy: 50,000 Hrs (at 25°C, 65%RH)
Motor Protection: Impedance protected
Safety Approvals: Meets UL, CSA, VDE Standards

CAT NO	PRICE EACH 1	10	25	100
CSA1225AC	$15.28	$12.94	$11.01	$9.88

Specifications

CAT NO	DIMENSIONS (MM)	NOMINAL VOLTAGE (V)	FREQUENCY (HZ)	SPEED (RPM)	INPUT POWER (W)	AIR FLOW (M3/MIN)	STATIC PRESSURE (MM)	NOISE LEVEL (dB)
CSA8038AC	80x80x38.5	110/120	50/60	2300/2600	9/7	0.63/0.72	3.5/4.5	31/34
CSA1225AC	120x120x25.5	110/120	50/60	2000/2300	12/10	1.56/1.70	4.6/4.8	23/36

Cool your 486 or Pentium CPU's with one of these CPU Cooling Fans.

NEW LOWER PRICES!!

CAT NO	DESCRIPTION	PRICE EACH 1	5	10
CC-M3	Cooling Fan for 486 CPU's	$7.50	$6.00	$5.00
PENTIUM FAN	Cooling Fan for Pentium CPU's (Will not fit Pentium 60 or 66MHz)	9.50	8.00	7.00

Plastic Fan Filter Assemblies

These fan filter packages consist of a guard, foam filter media and media retainer for tubeaxial fans. The retainer is easy to install without removing the fan or guard while the foam filter is also simple to clean and change. Use these kits to protect your equipment from airborn contamination and reduce external fan noise.

CAT NO	DESCRIPTION	PRICE EACH 1	10	25	50
GRM 60	Plastic Fan Filter Kit for 60mm Fans	$1.76	$1.42	$1.20	$ .98
GRM 80	Plastic Fan Filter Kit for 80mm Fans	2.20	1.75	1.48	1.28
GRM 92	Plastic Fan Filter Kit for 92mm Fans	2.60	2.05	1.74	1.40
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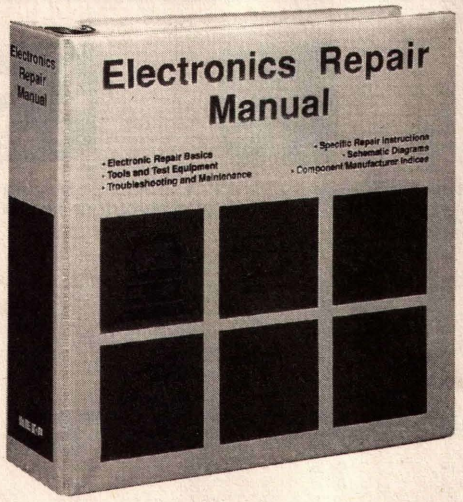

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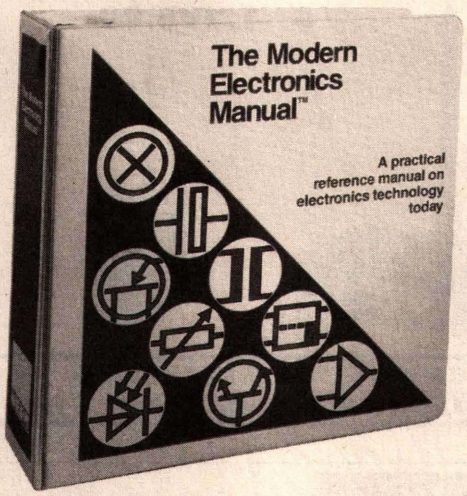

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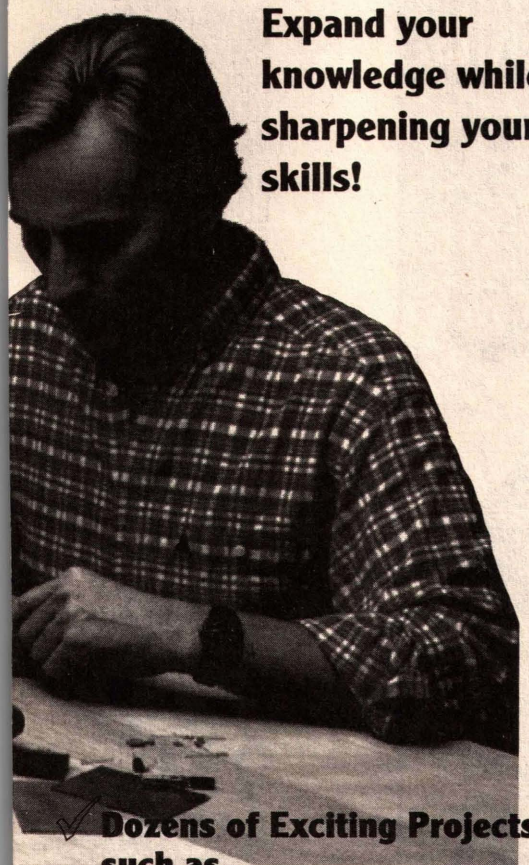

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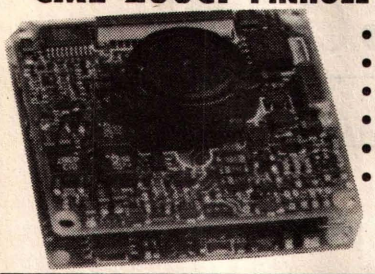

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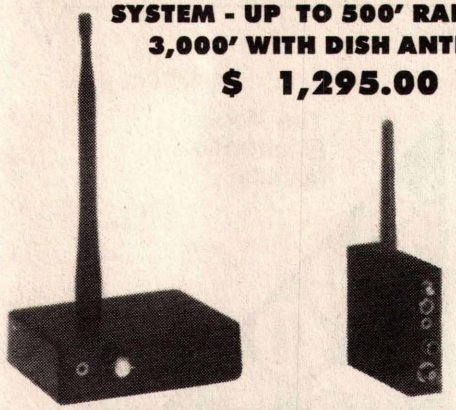

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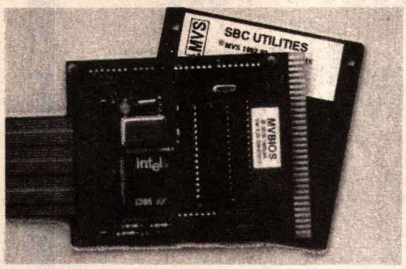

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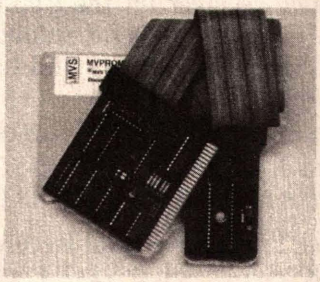

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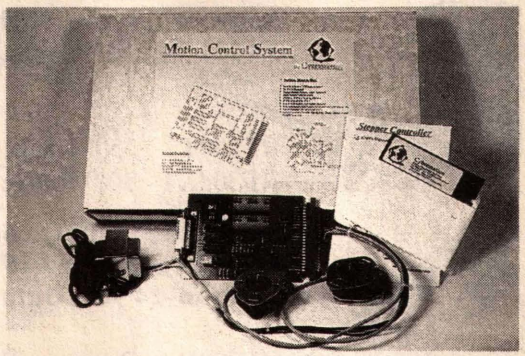

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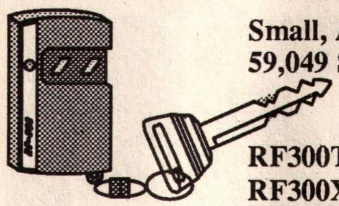

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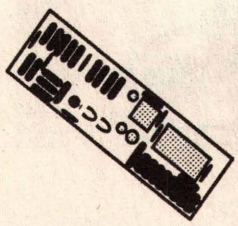

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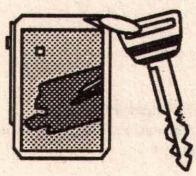

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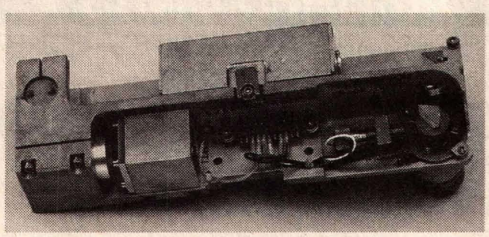

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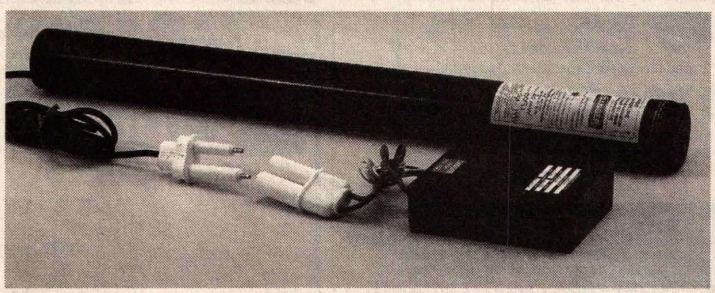

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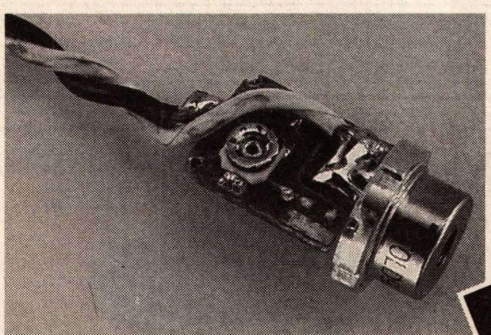

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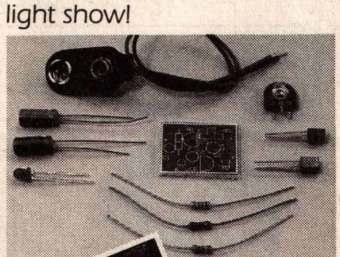

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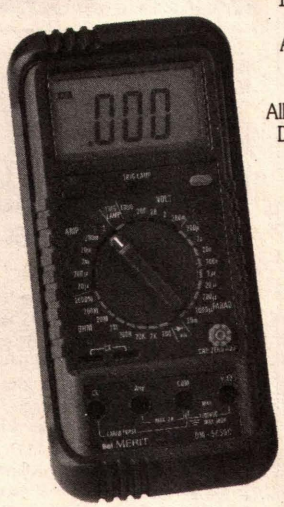

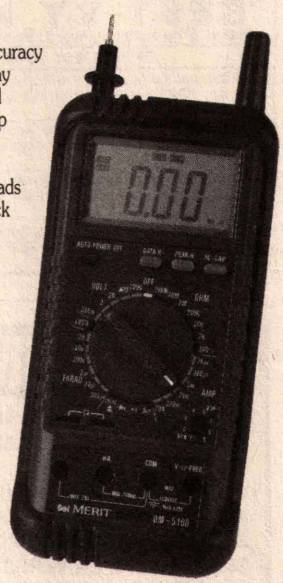

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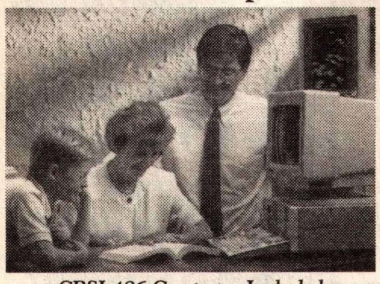

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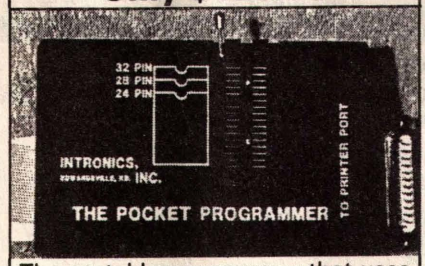

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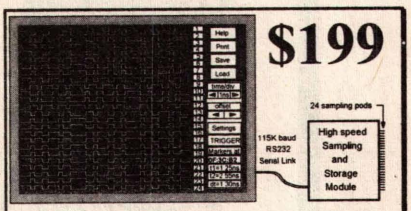

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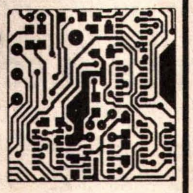

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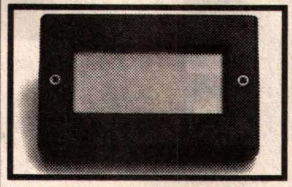

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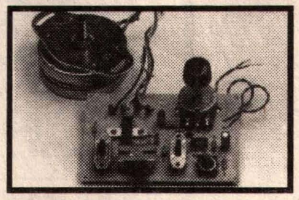

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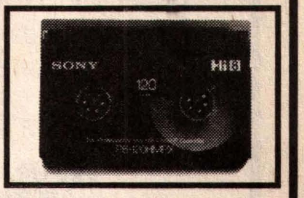

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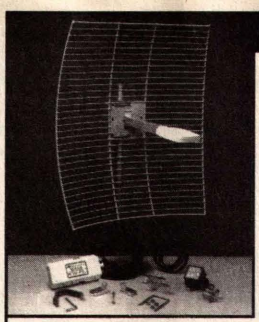

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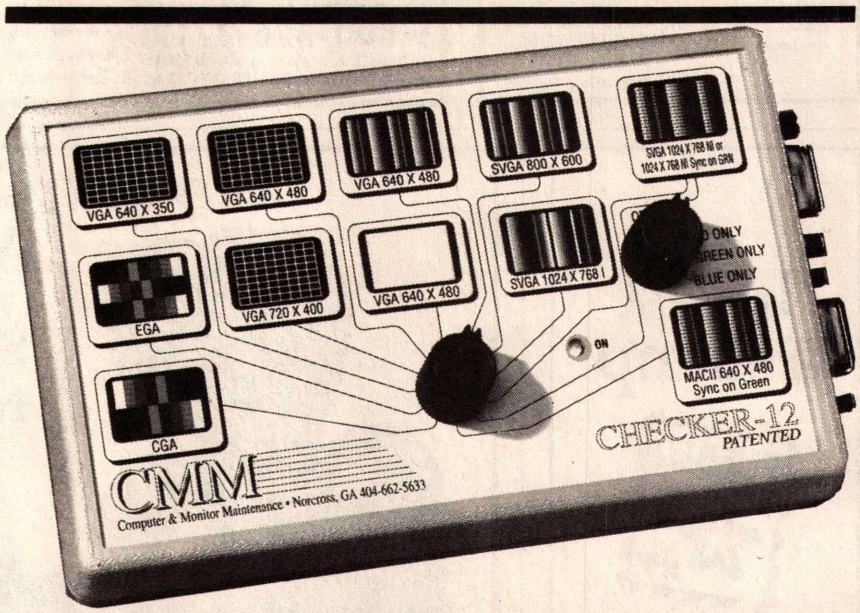

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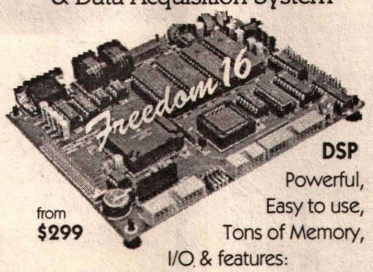

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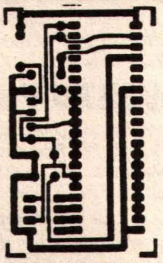

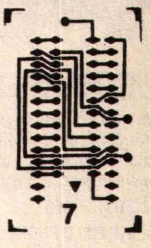

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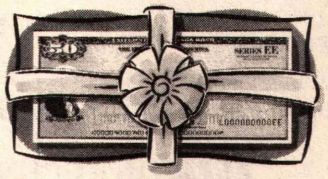

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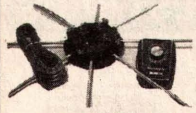

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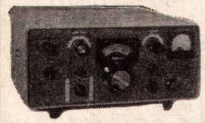

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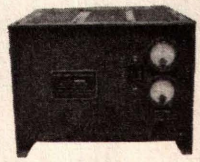

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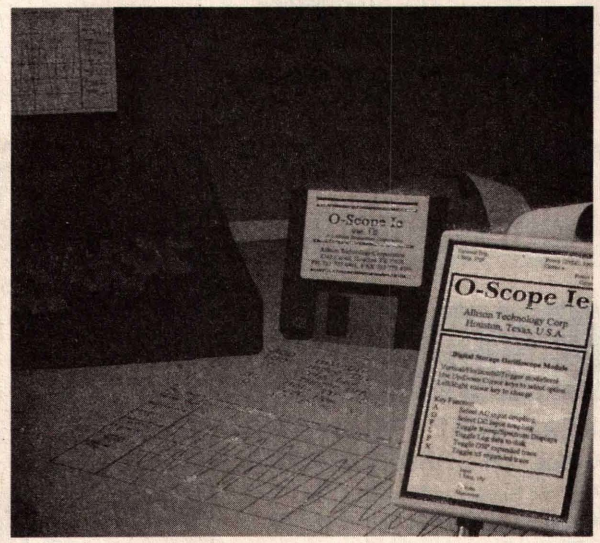

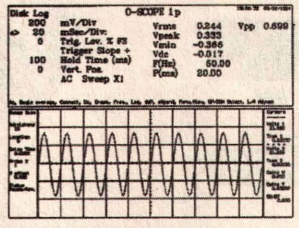

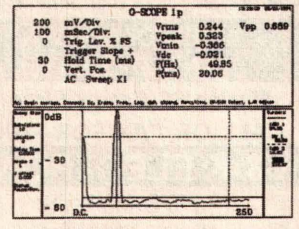

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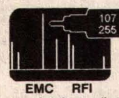

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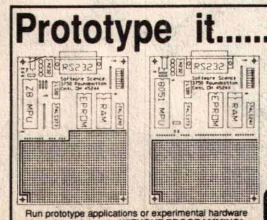

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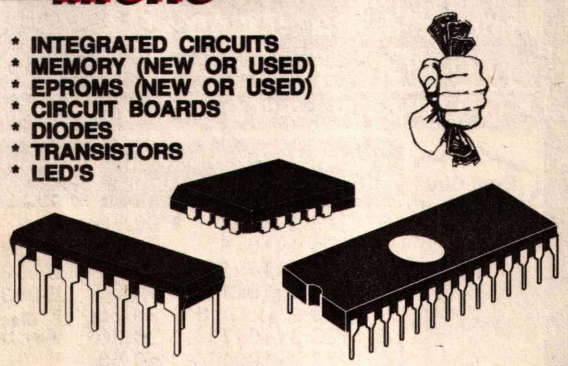

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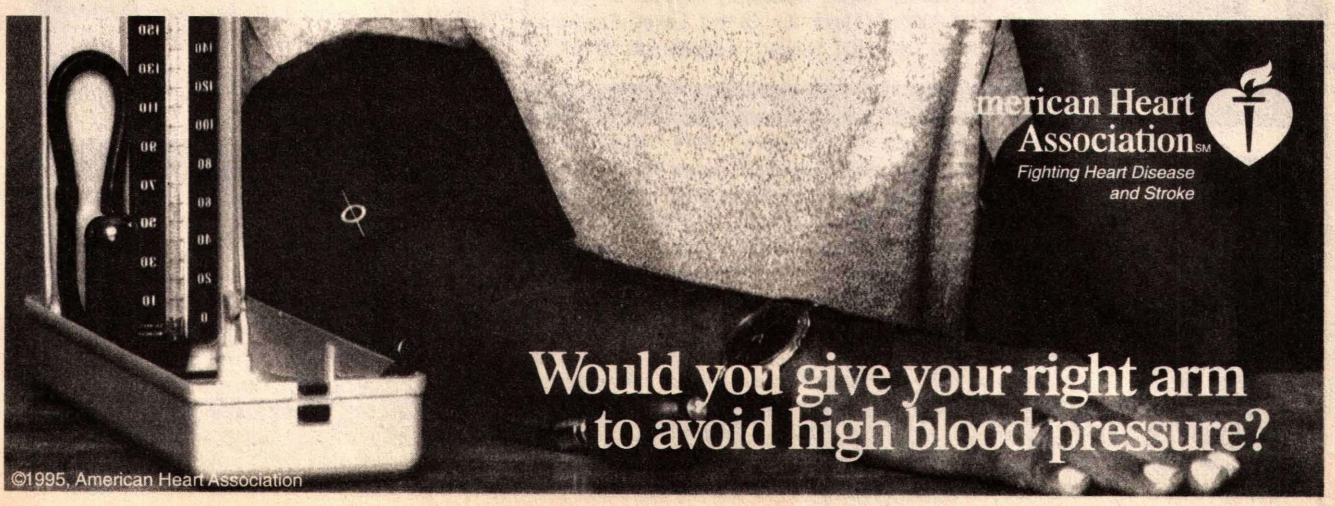

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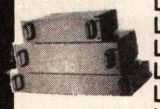

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LG-1684	4x16x8"	32.50
LG-1924	4x19x11½"	38.25
LG-1925	5x19x11½"	42.00
LG-1983	2¼x19x8"	35.25
LG-1923	3x19x11½"	36.50
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LG- Black anodized rack cabinet

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*LL-1923B	2¾x19x12"	69.50
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*LL- High quality full Aluminum Cabinet
*LL- Front panel .157" & other panels .078"

- **Dimensions in inches ± .05**
- **Custom-made for other dimensions if over 100 pcs for single model !**

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LE-453	4x4¾x3"	$ 7.50
LE-653	6x4¾x3"	9.75
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LE- Black finished aluminum panel 1mm thick.

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*LD-1244	2¾x10¾x4"	$55.00
**LD-1516	3¾x13¾x4"	29.50
**LD-1565	4x13¾x5¼"	31.75

*LD- Stainless Steel 0.7mm
**LD- Sheet Metal 1mm

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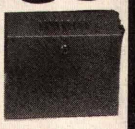

LB-1085	8¼x10¼x5"	$18.75
LB-1395	9¼x13¼x5"	25.50
LB-1525	12¼x15¼x5"	35.25
*LB-1494	9¼x14¼x4¼"	21.50
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001	28/30V x 2	6A	$ 30.00
002	36V x 2	3A	25.00
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**009	48/53V x 2	8A	66.00
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TA-800MK2 ▲▲ 120+120W Pre & Main Stereo Amp. (4 lbs.)

Kit:$ 67.92
Asmb.$ 86.95

Power Output:120W into 4 ohms RMS. 72W into 8 ohms RMS. Frequency Response:10-20KHZ. THD: <0.01%. Tone Control: Bass ±12dB, Mid & Treble ±8dB. Sensitivity: Phono Input, 3mV into 47K. Line, 0.3V into 47K. Signal to Noise Ratio: 86dB. Power Requirement: 40VDC @ 6A. Suggested Mark V model 001 or 008 transformer. Recommended Metal Cabinet LG-1924.

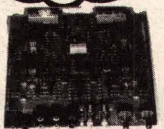
TA-1000A ▲▲ 100W Dynamic Class A Mono Amp (4 lbs.)

Kit:$ 54.00 Asmb.$ 74.00

Power Output: 100W into 8 ohms RMS, 125W into 4 ohms RMS. Frequency Response: 10HZ-100KHZ. THD: <0.008%. Signal to Noise Ratio:80dB. Sensitivity: 1V. Power Requirements: 35 to 45VDC @ 3A. Suggested Mark V model 001 or 008 transformer. Capacitor 10,000uf 80V model 016. Recommended Metal Cabinet LG-1924.

TA-388 ▲▲▲ Class A FET Dynamic Buffer Stereo Pre-Amp (1 lb.)

New

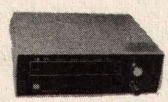


Kit:$64.00 Asmb.$ 80.00

Frequency Response (at rated output): Overall 10HZ-100KHZ +0.5dB-1dB. THD: Overall <0.007% at or below rated output level. Channel Separation (at rated output 1KHZ): Overall better than 70dB. Hum & Noise: Overall better than 90dB. Input Sensitivity (1KHZ for rated output): 300-600mV. Maximum Output Level: Pre-Amp output 1.8V (0.1% THD). Power Requirement: 30V X 2 AC 500mA.

SM-100 ▲▲▲ 150 MHZ 8 Digit Frequency Counter (2 lbs.)

New Release



Kit:$ 79.00
Asmb.$ 99.00

Frequency Range: 10HZ-150MHZ. Gate Time: 0.01s, 0.1s, 1s, 10s. Input Sensitivity: KHZ range 10HZ-10MHZ 20mV(min.). MHZ range 1MHZ-120MHZ 20mV(min.), 120MHZ-150MHZ 35mV (min.), 150MHZ-200MHZ 40mV(typical). Time Base: 10MHZ crystal, ±10 ppm. Input Impedance: 1M ohm. Response Time: 0.2s. Resolution: 0.1 HZ: 10s gate time, 1HZ: 1s gate time, 10HZ: 0.1s gate time, 100 HZ: 0.01s gate time. Hold the last input signal. Reset counter to 0. DC 9V power adapter or 1.5VX4"D"size batteries.(Adapter not included)

TA-50A/B ▲ Melody Generator

Clearance Sale

Kit:$ 13.85 $ 8.80

It uses the latest CMOS ROM technology and plays 8 different tunes. It operates on 2 AA size batteries due to its small current demand. You can adapt the generators to door bells, musical boxes, electronic clock alarms,etc. TA-50A: Jingle Bells... TA-50B: Happy Birthday...

TR-503▲ Regulated DC Power Supply

Kit:$ 18.75 Asmb.$ 27.65

It is short circuit proof and has overload protection. Output voltage is variable over a range of 0-50V. Current limit trip is adjustable up to max of 3A. Suggested Mark V 002 transformer. (1 lb.)

SM-302▲▲ 60+60W Stereo Power Amp

Kit:$ 75.00
Asmb.$ 94.00

It provides 3 input jack pairs. One pair accept a high impedance microphone. The two remaining pairs are for high & low level input sources. Power Output: 60W per channel into 4 ohms RMS. 20HZ-20KHZ. THD:<0.1%. Input Sensitivity: Mic/Guitar 10mV,Hi 380mV,Lo 640mV. Ready to plug in when assembled. (11 lbs.)

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TA-201	Mircophone Mixer Mono Amp.▲	20.79
TY-45	20 Bar/Dot Level Display ▲▲	41.45
TY-2	Flourescent Light Driver ▲	14.75

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Electronics NOW®

Volume 66

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Fibonacci's Sunflowers (Lancaster)(HH) Jul 75
Fieldpiece HS24K15 Stick Meter Fieldpack (ER) Oct 16
Five Easy EEPROM Projects (Xu) Nov 39
Floating a Battery (QA) Sep 7
Fluke GMM Graphical Multimeter (ER) Jul 16
FM RBDS Tuner (Lancaster)(HH) Apr 75
Fourier Series Analysis (Lancaster)(HH) Aug 77
Function Generator, Benchtop (Bergquist)(C) Nov 33

G

General-Purpose Controller Circuit for Audio Router (Grossblatt)(DB) Oct 55
Getting a Quick Fix, Or Service with a Smile (Klein)(AUD) Jan 85
Getting Connected to the Internet (Bigelow) Jul 31
GPS Navigation Update (Lancaster)(HH) Oct 47
Green PCs (Byers) May 31

H

Hacker PostScript Interface (Lancaster)(HH) Jan 77
Halogen Cycle Mysteries (Lancaster)(HH) Jan 77
Handy Hobby Power Supply (Spiwak)(C) Jun 43
HARDWARE HACKER (D)(Lancaster) Jan 77,Feb 75 Mar 79,Apr 75,May 81 Jun 73,Jul 75,Aug 77 Sep 46,Oct 47,Nov 114,Dec 41
- AC Power Drives May 81
- Acoustic Cancellations Jun 73,(Let)Nov 10
- "All-Channels" FM Transmitter Sep 46
- Another Patent Horror Story Nov 114
- Basic Stamp Manuals Jul 75
- DNA Computer Language, The Apr 75
- Fourier Series Analysis Aug 77
- Halogen Cycle Mysteries Jan 77
- Low-Cost TV Data Displays Mar 79
- Pseudoscience Strikes Again Dec 41
- Scientific Resource Feb 75
- Understanding Pitot Tubes Oct 47

Has DSS Been Hacked? (McCormac) Aug 33
Headphone Amplifier (QA) Jun 8,(LET)Sep 12
High
- and Low-Pass Active Audio Filters (Marston) Feb 61,(LET)Jun 12
- -Definition Compatible Digital Processing (Klein)(AUD) Oct 53
- -Power Hi-Fi Audio Amplifier (Metz & Boyce)(C) Oct 33,Nov 31
- -Tech Career for the '90s, A (Reis) Apr 63,(LET)Aug 12

HISTORY
- Microprocessors (Bigelow) Mar 35
- Scanning Early TV (Clifford) Jul 46
- X-Rays and Their Discoverer (Stroud and Sclater) Nov 29

Howler Substitute (QA) Jan 8
How to Solve All Your PC Problems (Holtzman)(CC) Sep 124

I

Incubator for Birds' Eggs (QA) May 8
Infrared Logic Probe (Firmani)(C) Dec 69
Intermittent Record Player (QA) May 8
INTERNET
- Directories (Lancaster)(HH) Oct 47
- Getting Connected to the (Bigelow) Jul 31

Isolation Transformer, Build an (Whisenant)(C) Jan 63

J

Jacob's Ladder (Iannini)(C) Dec 27

K

Keyboard Section of the All-Electronic Audio Router (Grossblatt)(DB) Jun 82
KIT BUILDING
- Elenco Electronics FO-30 Fiber Optics Kit (ER) Apr 14
- Sescom CT-6 Cable Tester Kit (ER) Sep 15

L

Laser
- Light Show (Williams)(C) Apr 33,(LET)Oct 14
- Phonograph (QA) Jul 8,(LET)Oct 14

L-C Bridges (Marston) Oct 43
LETTERS (D) Jan 10,Feb 12,Mar 14,Apr 12 May 10,Jun 12,Jul 12,Aug 12 Sep 12,Oct 14,Nov 10,Dec 10
Letters: Bouquets and Brickbats (Klein)(AUD) May 89
Light Controller Interference (QA) Feb 10
Light Turn-on Circuit (QA) Jul 8
Listening Tests: Sex and the Experienced Listener (Klein)(AUD) Aug 84
Logic Analyzer, Mini (Barbarello)(C) Feb 47,(LET)Jul 12
Logic Probe, Infrared (Firmani)(C) Dec 69
Long Cable Runs (QA) Jan 8
Low-Cost
- Software for Electronics (Byers) Sep 33,Oct 35
- TV Data Displays (Lancaster)(HH) Mar 79

Low-Power Clock (QA) Mar 8

M

Magic
- Digital Sinewave Codes (Lancaster)(HH) Apr 75
- Sinewaves (Lancaster)(HH) Nov 114

Magnetic Storage Tips (Rabin) May 68
Matching Resistors and Capacitors, Bridges (Marston) Nov 41
Memory, Recycling, for Your PC (Schmidt)(C) Sep 35
Meter Faces, Custom (Withrow)(C) Apr 51
Meter Shunts (QA) May 8,(LET)Sep 12
Microcontroller Help (QA) Jun 8
Microprocessors (Bigelow) Mar 35
Mid-Range Mensch Converter (Lancaster)(HH) Nov 114
MIDI Music Book (Lancaster)(HH) Dec 41
Milliohm Tester, Build This (Heil)(C) Feb 59,(LET)May 10
Mini
- Logic Analyzer (Barbarello)(C) Feb 47,(LET)Jul 12
- Radio Station (QA) Apr 8

Modular DC-to-DC Converters (Eichenberg) Dec 37
Monitor Switcher (QA) Apr 8,(LET)Jun 1
More Magic Sinewaves (Lancaster)(HH) May 81
More Miscellaneous Matters (Klein)(AUD) Nov 120
Motherboard Misery (QA) Mar 8
Multimeter, Graphical, Fluke GMM (ER) Jul 16
Music Vision (Kraft)(C) Nov 23
Mystery Band (Lancaster)(HH) Oct 47
"Mystery Band" Opportunities (Lancaster)(HH) Feb 75

N

Narrow Tunable Bandpass Filter (Lancaster)(HH) Sep 46
Negative Regulator (QA) Apr 8
Neon Power (QA) Feb 10
Network Card Settings (QA) Jul 8
New BASIC Stamps (Lancaster)(HH) May 81
NEW LITERATURE (D) Jan 25,Feb 26,Mar 28 Apr 26,May 24,Jun 24,Jul 26,Aug 22 Sep 127,Oct 26,Nov 20,Dec 24
NEW PRODUCTS (D) Jan 29,Feb 22,Mar 18 Apr 22,May 15,Jun 20,Jul 22,Aug 18 Sep 20,Oct 18,Nov 16,Dec 19
NewTek's Video Toaster (Lancaster)(HH) Aug 77
Nine-Channel Remote Control (Caristi)(C) Jun 49
No Hot Boot (QA) Apr 8
NPN Transistor Dilemma (QA) Oct 8

O

Off-Line Regulators (Connell)(C) Apr 71,(LET)Aug 12
"Old" Circuits and a Brand New Topic (Grossblatt)(DB) Mar 86
Online Services (Lancaster)(HH) Feb 75
Op-Amp Antenna Amplifier (QA) Sep 7
Operational Amplifiers (Marston) Jan 58
Oscilloscope, Protek P-3502C (ER) Feb 16
Over/Under-Voltage Protector (Tipton)(C) Sep 39

P

Password Swap (QA) Oct 8
PC
- Board for the Audio Router (Grossblatt)(DB) Aug 86
- Cards (Bigelow) Jun 31
- Clinic SB, Data Depot's (ER) Dec 13
- Thermometer (QA) Oct 8

PCs, Green (Byers) May 31

PCMCIA Card Resources (Lancaster)(HH) **Nov 114**
Phantom of the Ether (Heald) **Jan 53**
PHOTOGRAPHY
Seeing the Unseen (Condax) **Oct 45**
Video Inverter (Sousa)(C) **Jul 41**
PIC Microprocessor
Fundamentals (Lancaster)(HH) **Jun 73**
Resources (Lancaster)(HH) **May 81**
Picking a New Microcontroller (Lancaster)(HH) **Oct 47**
Plated Through Hole Alternatives (Lancaster)(HH) **Aug 77**
Programmable Interconnects (Lancaster)(HH) **Jan 77**
PocketPOST Diagnostic Card (ER) **Nov 13**
Power
Control
Circuits (Marston)(C) **Jun 59**
Synchronous (Marston) **Jul 63**
Controller, Build This (Roane)(C) **Jan 68,(LET)Mar 14,(LET)May 10**
Pincher, The (Lashansky)(C) **May 43**
Semiconductors (Sclater) **May 57**
Supply
Handy Hobby (Spiwak)(C) **Jun 43**
Regulated, for Electrochemistry (Barrow)(C) **Dec 29**
Versatile (Bergquist)(C) **Dec 31**
Precision Audio Signals from your PC (Covington)(C) **Feb 44**
ProCar Security System, The (Miga)(C) **Feb 35,Mar 65,May 71,Jun 67**
Programmable Sinewave Generator, Build This (Portugal)(C) **Jan 43,(LET)Mar 14**
Protek P-3502C Oscilloscope (ER) **Feb 16**
Prototyping Station (Bergquist)(C) **Mar 54**
Pseudoscience Strikes Again (Lancaster)(HH) **Dec 41**
Put That Phone on Hold! (Montegari)(C) **Apr 39**

Q

Q&A (D) **Jan 9,Feb 10,Mar 8,Apr 8 May 8,Jun 8,Jul 8,Aug 8 Sep 7,Oct 8,Nov 8,Dec 8**

R

RADIO
Radio
Hacker's Delight (QA) **Dec 8**
Receiver (Lancaster)(HH) **Mar 79**
Wave Source (QA) **Jun 8**
WWV Receiver (Heckt)(C) **Mar 49,(LET)Jun 12**
Random Thoughts on Miscellaneous Matters (Holtzman)(CC) **Dec 52**
Ready-to-Use Transmitter (QA) **Apr 8**
Receiver, WWV (Heckt)(C) **Mar 49,(LET)Jun 12**
Recycling Memory for Your PC (Schmidt)(C) **Sep 35**
Regulated Power Supply for Electrochemistry (Barrow)(C) **Dec 29**
Regulators, Off-Line (Connell)(C) **Apr 71,(LET)Aug 12**
Remote-Control
Adapter (Weeder)(C) **Aug 41**
Carrier-Current (Caristi)(C) **Jun 49**
Output, Analyzing (Hamilton)(C) **Aug 50**
Repeater (QA) **Dec 8**
Retreat of the Barbarians (Holtzman)(CC) **May 27**
RISC vs. CISC (QA) **Aug 8**
Robot Controller (QA) **Jan 8**

S

SATELLITE TV
Has DSS Been Hacked? (McCormac) **Aug 33**
Satellite Signal Piracy: The European Experience (McCormac) **Aug 37**
Scanner Modifications (QA) **May 8**
Scanning Early TV (Clifford) **Jul 46**
Science Versus Pseudoscience (Lancaster)(HH) **Jan 77**
Scientific Resource (Lancaster)(HH) **Feb 75**
Security System, The ProCar (Miga)(C) **Feb 35,Mar 65 May 71,Jun 67**
Seeing the Unseen (Condax) **Oct 45**
Semiconductors, Power (Sclater) **May 57**
Sencore CM125 Computer Monitor Signal Generator (ER) **Mar 16**
Sequential LEDs (QA) **Nov 8**
Servicing Intermittent Problems (Lancaster)(HH) **Feb 75**
Sescom CT-6 Cable Tester Kit (ER) **Sep 15**
Shutdown Circuits (Rodgers) **Nov 122**
Signal
Monitor (QA) **Jul 8**
Piracy, Satellite: The European Experience (McCormac) **Aug 37**
Theft (Paradise) **Jan 35,(LET)Apr 12,May 10**
Sinewave
Doubler (Swift)(C) **Feb 55**
Generator, Programmable (Portugal)(C) **Jan 43,(LET)Mar 14**
Slide Stepper, The (Swancara)(C) **May 91**
SMD Removal Kit, Chip Quik (ER) **Aug 16**
Software for Electronics, Low-Cost (Byers) **Sep 33,Oct 35**
Solder/Desolder Station, A.P.E. SMD-250 (ER) **May 14**
Solid-State Thermometer (Spiwak)(C) **Mar 45**
State Machines (QA) **Dec 8**
Subwoofer for Your Car, Build This (Rumreich)(C) **Oct 41**
Stepper-Motor Driver Chips (Lancaster)(HH) **Nov 114**
Switch Selector Circuit for the Audio Router (Grossblatt)(DB) **Jul 83**
Surface-Mount Removal (Lancaster)(HH) **Jun 73**
Sweep Alignment—Lost Art? (QA) **Jun 8,(LET)Oct 14**
Switched Capacitor IC Resources (Lancaster)(HH) **Sep 46**
Synchronous Power Control (Marston) **Jul 63**

T

Tachometer Circuit, Add a 3-Digit Display (Grossblatt)(DB) **Feb 87**
Taming the Deafening Decibels (Klein)(AUD) **Jun 81**
Practicing "Safe Sound" (Klein)(AUD) **Jul 81**
TELEPHONE
Call Counter, The (Stern)(C) **Jun 48**
Telco in a Box (Cicon)(C) **Sep 43,(LET)Nov 10**
Telephone
Cost Meter (Rahhal)(C) **Apr 55**
Hold Circuit (Montegari)(C) **Apr 39**
Ten Years of Progress—For Better or Worse (Holtzman)(CC) **Feb 89**
TEST EQUIPMENT
Benchtop Function Generator (Bergquist)(C) **Nov 33**
Budget Capacitance Meter (Babcock)(C) **Jun 55**
Build A
Chip Tester (Hanslip)(C) **Jan 41**
Super-Simple Audio/Video Cable Tester for Under $10 (Klein)(AUD) **Apr 83,(LET)Sep 12**
Build This
Milliohm Tester (Heil)(C) **Feb 59,(LET)May 10**
Programmable Sinewave Generator (Portugal)(C) **Jan 43,(LET)Mar 14**
Cable Tester (Barbarello)(C) **Jul 69**
Custom Meter Faces (Withrow)(C) **Apr 51**
dB Meter (Pivnichny)(C) **Nov 112**
Dual-Trace Converter (McIntire)(C) **Jun 46**
Fieldpiece HS24K15 Stick Meter Fieldpack (ER) **Oct 16**
Fluke GMM Graphical Multimeter (ER) **Jul 16**
Infrared Logic Probe (Firmani)(C) **Dec 69**
Mini Logic Analyzer (Barbarello)(C) **Feb 47,(LET)Jul 12**
Protek P-3502C Oscilloscope (ER) **Feb 16**
Sencore CM125 Computer Monitor Signal Generator (ER) **Mar 16**
Sescom CT-6 Cable Tester Kit (ER) **Sep 15**
Sinewave Doubler (Swift)(C) **Feb 55**
Voltage Cursor Adapter (Campisi)(C) **May 65**
Thermal Cutout (QA) **Jun 8**
Thermometer, Solid-State (Spiwak)(C) **Mar 45**
Tone Decoder (QA) **May 8**
Transistor Switching Circuits (QA) **Dec 8**
Troubleshooting Shutdown Circuits (Rodgers) **Nov 122**
TRS-80 Forever? (QA) **Sep 7**
TELEVISION
Scanning Early TV (Clifford) **Jul 46**
TV Scope (QA) **Jul 8**

U

UberSoft Uber Alles (Holtzman)(CC) **Mar 92**
Unauthorized Windows (Holtzman)(CC) **Apr 90**
Understanding Pitot Tubes (Lancaster)(HH) **Oct 47**
Universal Clock (Tarchinski)(C) **Jun 37**

V

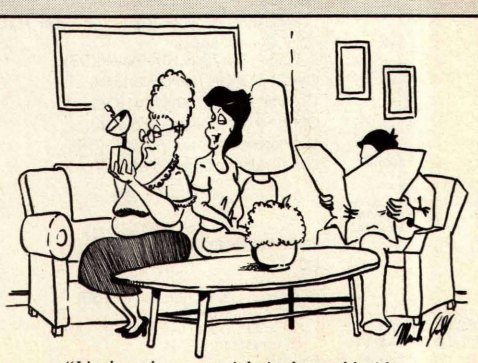
Variable Duty Cycle (QA) **Jun 8,(LET)Sep 12,Aug 8**
Vector-to-Step Conversions (Lancaster)(HH) **Jan 77**
Versatile Power Supply (Bergquist)(C) **Dec 31**
VIDEO (See also SATELLITE, TELEVISION, VIDEO NEWS)
VCR Modification (QA) **Apr 8**
Video
Inverter (Sousa)(C) **Jul 41**
Receiver, Experimenter's (Botts)(C) **Dec 33**
Titler, Build This (Michelson)(C) **May 49**
VIDEO NEWS (D)(Lachenbruch) **Jan 6,Feb 6,Mar 6 Apr 6,May 6,Jun 6,Jul 6,Aug 6 Sep 6,Oct 6,Nov 6,Dec 6**
Voltage
Converters (Marston)(C) **Apr 42,(LET)Jul 12**
Cursor Adapter (Campisi)(C) **May 65**
Indicator (QA) **Jul 8**
Protector, Over/Under (Tipton)(C) **Sep 39**

W

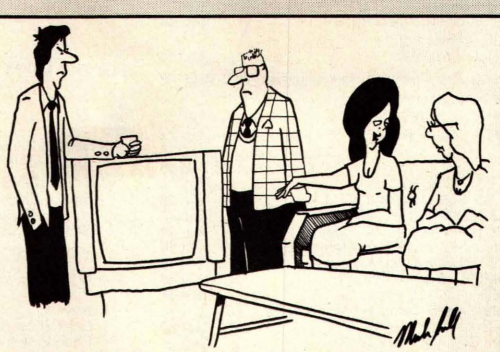
Walkie-Talkie Modification (QA) **Aug 8**
Waveform Generator Circuits (Marston) **Dec 35**
Wavelet Book References (Lancaster)(HH) **Apr 75**
WHAT'S NEWS (D) **Jan 4,Feb 4,Mar 4,Apr 4 May 4,Jun 4,Jul 4,Aug 4 Sep 4,Oct 4,Nov 4,Dec 6**
Wind Monitor (Leonik)(C) **Aug 57**
Windows 95 Update (Holtzman)(CC) **Oct 61**
Windows and Warp, Delphi, and the P6 (Holtzman)(CC) **Jun 84**
WinHEC '95 (Holtzman)(CC) **Jul 85**
Wireless Frequencies (QA) **Feb 10**
Working with Smart Displays (Lettow)(C) **Jul 51**
WWV Receiver (Heckt)(C) **Mar 49,(LET)Jun 12**

X

X-Rays and Their Discoverer (Stroud and Sclater) **Nov 29**



"It's the only paperweight in the world with five megabits of RAM."



"Everything Tom builds is energy-efficient. None of it works."

continued from page 26

brary comes with over 200 components, including a good assortment of connectors and SMD (surface mounted device) footprints. New parts can be added to the library using a library editor. Parts can be selected from the library by name or by highlighting them from a library menu. A browse menu lets you see the components before you lay them down, which eliminates a lot of guess work. Once a device is selected, it may be repeated as many times as you wish.

Tracks may be placed manually or by using the pad-to-pad autorouter. Unlike a conventional autorouter, this single-minded heuristic router uses a very clever algorithm to find an unimpeded path between two specified pads—unless, of course, you've somehow managed to paint yourself into a corner. Getting blocked is hard to do because the router will use all available layers when plotting a path. The router supports six copper layers and two ground planes, and does its own via placement. Unfortunately, the router investigates orthogonal paths only, which may result in a number of vias that aren't really needed—vias that you will have to optimize on your own. When routing manually, the tracks may be orthogonal, free style, or curved. Track width is selectable in seven increments from 10 to 100 mils for both manual and autorouting, but you cannot change the width on the fly.

All commands can be accessed either through pull down menus or by using keyboard shortcuts. Screen panning is automatic anytime you hit against the edge of the screen, and the zoom function is available during placement and routing. Block functions include move, rotate, copy, delete, hide, and save. Objects may be rotated and flipped (except SMD devices) before and after placement.

Final artwork may be produced on either a dot-matrix or laser printer. Several plotters are supported, too. In addition to layer hardcopy, Easytrax generates artwork for silk-screen, solder, and SMD-paste masks. Easytrax also generates Gerber and Excellon N/C Drill files.

So if you think it's time to reward yourself with that free lunch you've been dreaming of, help yourself by downloading Easytrax from the Internet, Protel's bulletin board, or the Electronics Now BBS (516-293-2283) under the filename EASYTRAX.ZIP.

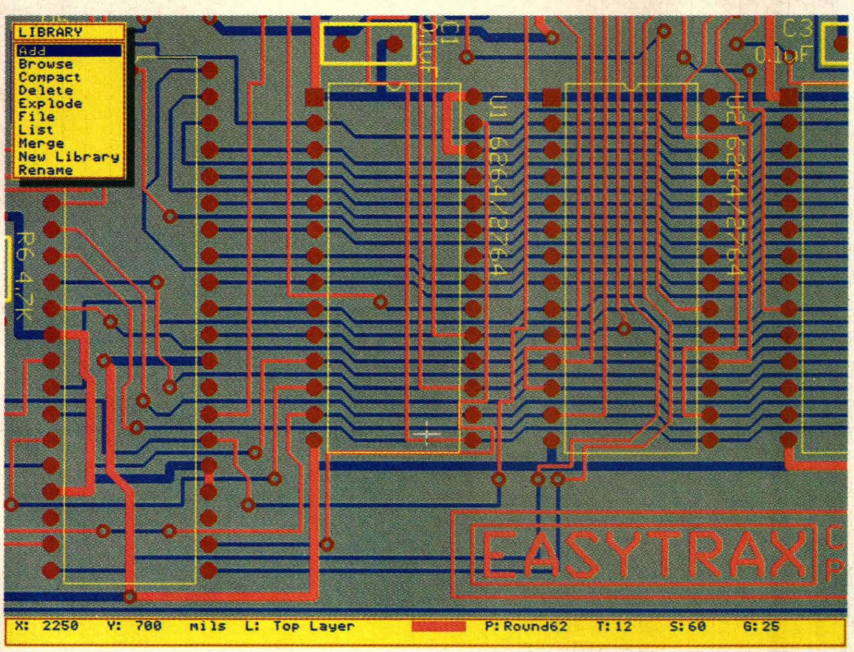


FIG. 3— NO FREE LUNCH? HARDLY. EASYTRAX is an example of what you can get for free. It comes with over 200 library components, which are connected by a pad-to-pad autorouter that uses a clever algorithm to find an unimpeded path between pads.

Product:	PCAD
Version:	2.2
Price:	$65
Platform:	DOS
Distributor:	Micronics Technology

Priced at just $65, PCAD from Micronics Technology is a low-cost PC-board layout program targeted for the casual project maker and hobbyist. The DOS-based program lets you build PC boards up to 20 by 9.8 inches in size on two layers of copper—quite adequate for most of the projects found in the pages of *Electronics Now*. The simplicity of its operation and the no-frills approach make PCAD ideal for users who have little or no experience with making printed circuit boards.

PCAD's library has no devices, *per se*. Instead, component footprints are made using pads, lines, and accompanying nomenclature, which are saved as a block. In fact, this is the method we used to construct the connectors J1 through J4, as well as resistors R1 through R6. After the footprint is defined, it is saved to a file in a "library" directory, where it can be retrieved and used again. However, blocks cannot be rotated, which means you'll have to define a separate block for each different orientation. For example, the vertically-oriented chip IC2 (U2) used in the benchmark layout is saved as DIP14V, while its horizontal counterpart is called DIP14H.

PCAD comes with a large assortment of schematic symbols that can be used to identify parts in the silk-screen layer. Resistors R1 through R6 are a single block made up of two pads and a horizontal resistor symbol. If you wish, a part value, like 2.2K, can be added to the block. The component's annotation is added later by hand; auto annotation is not pro-

TABLE 1

	BoardMaker I	CADPAK II PCB II	Circuit Layout	DC/CAD	Easy-PC	Easy-PC Pro	Easytrax	EZ-Route Std EZ-Logic	PCAD	PCBoards	SuperPCB for Windows	TurboCAD
Price	$95	$159	$80	$295	$145	$349	Free	$249	$65	$99	$299	$129
Format	DOS	DOS	DOS	DOS	DOS	DOS	DOS	Windows	DOS	DOS	Windows	Windows
RAM required	512K	640K	512K	640K	512K	640K		512K	640K	512K	4MB	2MB
Hard disk required	N	2MB	5MB	5MB	N	5MB	N	3MB	N	N	2MB	4MB
Maximum board size (inches)	17 x 17	30 x 30	16 x 10	32 x 32	17 x 17	32 x 32	32 x 32	8 x 10	20 x 9.8	6 x 13	16 x 8	
BBS file		ISISDEMO.EXE				EASY-PC.ZIP	EASYTRAX.ZIP				SUPERCAD.ZIP	
Schematic capture												
Included	Y	Y	N	Y	Y	Y	N	Y	N	N	Y(4)	Y(4)
Linked	N	N	N	Y	N	Y	N	Y	N	Y(3)	Y	N
Design rule check	Y	N	N	Y	N	Y	N	Y	N	N	Y	N
PCB Layout												
Automatic part placement	N	N	N	Y	N	Y	N	Y	N	N	Y	N
Repeat part placement	Y	Y	Y	Y	N	Y	Y	Y	Y(1)	N	N	Y
Rotate part prior to place	N	N	Y	Y	N	Y	Y	Y	Y(1)	N	N	Y
Zoom on-the-fly	Y	Y	Y	Y	Y	Y	Y	Y	N	N	N	Y
Auto pan	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	N	Y
Routing Features												
Autorouter available	N	N	N	Y	N	Y	N	Y	N	Y	Y(5)	N
Ratsnest	N	N	N	Y	N	Y	N	Y	N	N	N	N
Pad-to-pad router	N	N	Y	N	N	N	Y	N	N	N	Y	N
Mixed track widths	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y
Freehand tracks	N	N	N	N	N	Y	Y	Y	N	N	N	N
Camfered corners	Y	Y	N	Y	Y	Y	N	Y	Y	N	Y	Y
Curved tracks	Y	N	N	N	N	Y	Y	Y	N	N	Y	N
Neck down	Y	Y	Y	N	N	Y	N	N	N	N	Y	Y
Number of copper layers	8	2	2	64	8	14	8	6	2	2	2	16
Auto vias	Y	Y	N	Y	Y	Y	Y	Y	Y	N	Y	N
Blind vias	Y	n/a	n/a	Y	Y	Y	Y	Y	n/a	n/a	n/a	N
Buried vias	Y	n/a	n/a	Y	Y	Y	Y	Y	n/a	n/a	n/a	N
Ground/power planes	N	n/a	n/a	Y	N	N	Y	Y	n/a	n/a	n/a	Y
Library												
Screen directory	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y
Part preview	Y	N	N	N	N	N	Y	Y	N	N	Y	Y
Editing Features												
Modify track width	Y	Y	Y	Y	N	Y	Y	Y	N	Y	Y	Y
Change pad size/style	Y	Y	N	Y	N	Y	Y	Y	N	Y	Y	Y
Block												
Copy	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y
Move	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Rotate	Y	Y	N	Y	Y	Y	Y	Y	N	Y	Y	Y
Save	N	Y(2)	N	Y	N	N	Y	Y	Y	Y	N	Y
Output formats												
Dot-matrix printer	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Laser printer	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
HPGL plotter	Y	Y	N	Y	Y	Y	Y	Y	N	Y	Y	Y
Gerber	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	N
N/C Drill	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	N

1) DIP ICs only
2) Route tracks only
3) Has netlist conversion utility
4) Extra cost
5) Included

vided. Blocks are easily modified by simply editing the footprint after it's placed on the circuit board. The block doesn't have to be exploded or unlocked for editing; edited blocks can be saved as the original or to a new block name.

While you can use library blocks to hold IC footprints, it's just as easy to create them using the DIPs editor. The process is as easy as calling up the menu, entering the number of pads, and their spacing. The pads come in 11 different sizes and shapes, including surface-mount pads, which are selected via the TYPE button. The chip can be rotated in 90-degree increments prior to placement. (See Fig. 4.) Once a pattern is defined, it may be placed as many times as you wish with a single mouse click.

Tracks come in four widths only, and are drawn by holding down the left mouse button and scooting the mouse. The track is visible during the drawing process, and it can be generated with 45-degree corners for easier fabrication and reduced RFI radiation. Deleting tracks is a simple matter of clicking on the right mouse button. There are no menus to load or navigate.

In fact, PCAD has very few menus. With a couple of exceptions, everything is done using the keyboard. For example, pads are placed on the board using the F5 through F12 keys, track width is changed using <Ctrl><S>, and <Alt><R> redraws the screen. The silk-screen symbols are also placed via the keyboard. Unfortunately, the number of keyboard functions are far too numerous to commit to memory—especially if you don't use the program regularly. You'll want to keep the manual handy, or, better yet, have a chart of the key functions tacked on a nearby wall.

A real annoyance with PCAD is the lack of a zoom function, which prevents a full view of the board. Fortunately, there are two features that make it less bothersome: auto pan which shifts the board up, down or sideways when the cursor bumps against the screen's

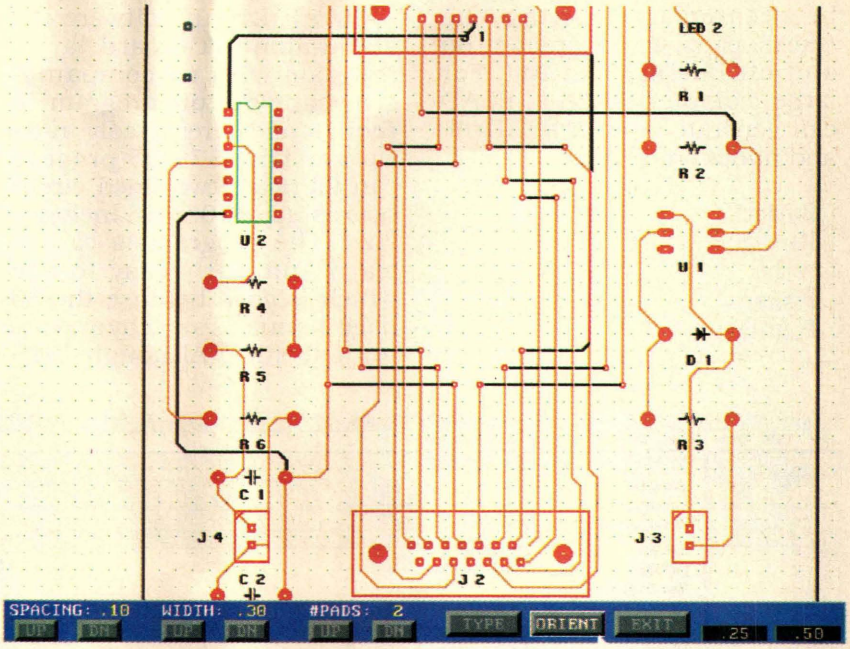


FIG. 4— PCAD'S COMPONENT ARE MADE using pads, lines, and accompanying nomenclature, which are saved as a block. This is the method we used to construct connectors J1 through J4.

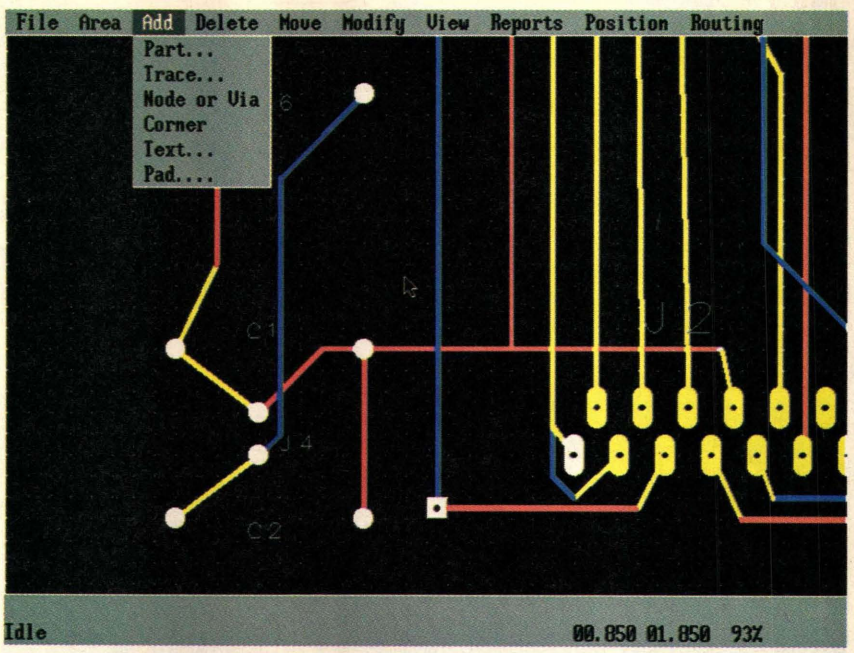


FIG. 5—PC LOGIC IS A STAND-ALONE PC-BOARD LAYOUT program with a pad-to-pad autorouter. Future editions will include a schematic capture companion.

edge, and the ability to display the board at resolutions of 1024 by 768. At 1024 by 768, the visible board area is about 4 by 6 inches, or about one-ninth the total working space. This compares to a viewing area of 3 by 4 inches for standard VGA resolution (640 by 480), which is about one-eighteenth the total working space.

PCAD supports only two output devices: HP LaserJet printers and 24-pin, Epson dot-matrix printers, or their equivalent. Each foil pattern is printed separately, and the images can be rotated and mirrored. Dot-matrix printouts are two times the actual size, and laser prints are actual size. While PCAD has no dedicated options silk-screen or solder-mask printing option, they can

be created by turning the tracks, pads, and characters on and off during printing. For large, complex designs, PCAD can generate Gerber, N/C Drill, and photoplotter files.

Product:	Circuit Layout
Version:	1.1
Price:	$79.95
Platform:	DOS
Publisher:	PC Logic

Circuit Layout software is a stand-alone PC-board layout program with no companion schematic capture program, although one is reportedly in the works. This $79.95 program can fabricate two-sided circuit boards up to 10 by 16 inches in size. The program is easy to learn and fairly easy to use, which is good because the 30-page manual is sketchy and way too succinct. Although DOS-based, Circuit Logic has the look and feel of a Windows program. All operations are accomplished with pull-down menus. Clicking on a menu heading opens up a list of options; to select an option you need to hold down the mouse button and drag the highlight to the desired function. Releasing the button activates the command.

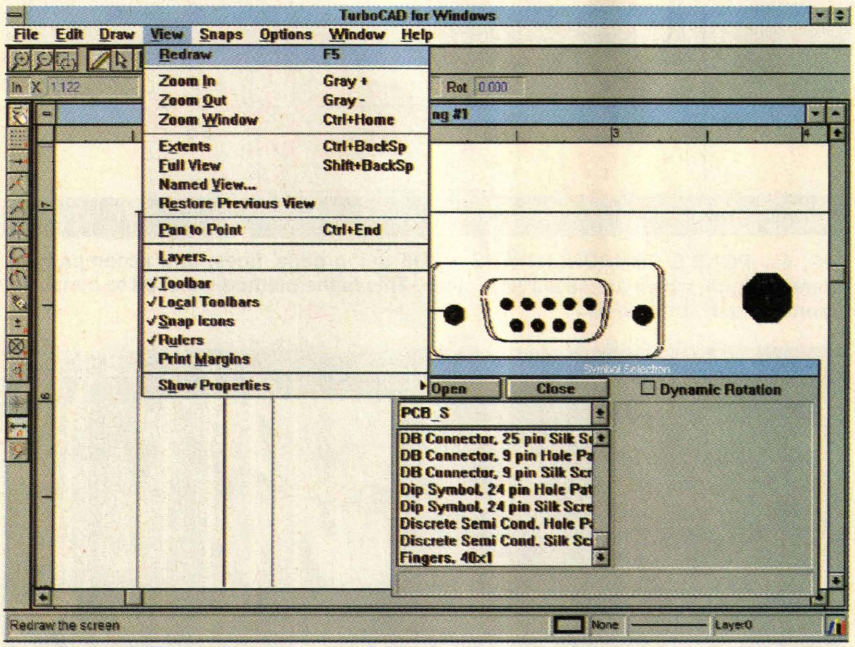


FIG. 6—TURBOCAD'S PRINTED CIRCUIT COMPONENTS are contained in an optional $29.95 symbol library

Parts are placed on the circuit board using the Add option (Fig. 5). The Circuit Layout library contains about 50 devices. Despite the low part count, the variety of devices is quite diverse, and includes surface mount devices as well as a hearty helping of DIPs and DB-shell connectors. Unfortunately, the library doesn't have footprints for capacitors or resistors; they are made using pads, which are available from the same menu. Fortunately, it's easy enough to create or modify existing parts using the Parts Editor. For example, the library lacks a 6-pin DIP. No problem. The part was quickly made by deleting two pads from the 8-pin DIP footprint. Once an item is selected from the library, it can be placed repeatedly.

Tracks can be placed manually or by using the pad-to-pad autorouter. Like the Easytrax pad router, the Circuit Layout router can normally find an unimpeded path between two specified pads. Unlike Easytrax, though, it doesn't have automatic via placement. All routing is done on one side of the board. In fact, there is no automatic via support. If you want to change sides, you have to manually add the via, then modify the track using the Modify command. When laying down tracks manually, the track is drawn as a straight line between the two pads, cutting across devices and other tracks. It's up to you to use the Corner and Move commands to route the track or use the expertise of the autorouter to do it for you. A nice feature is the ability to change track width between vias—a feature that mimics necking down for scooting traces between adjacent pads.

Circuit Layout supports only

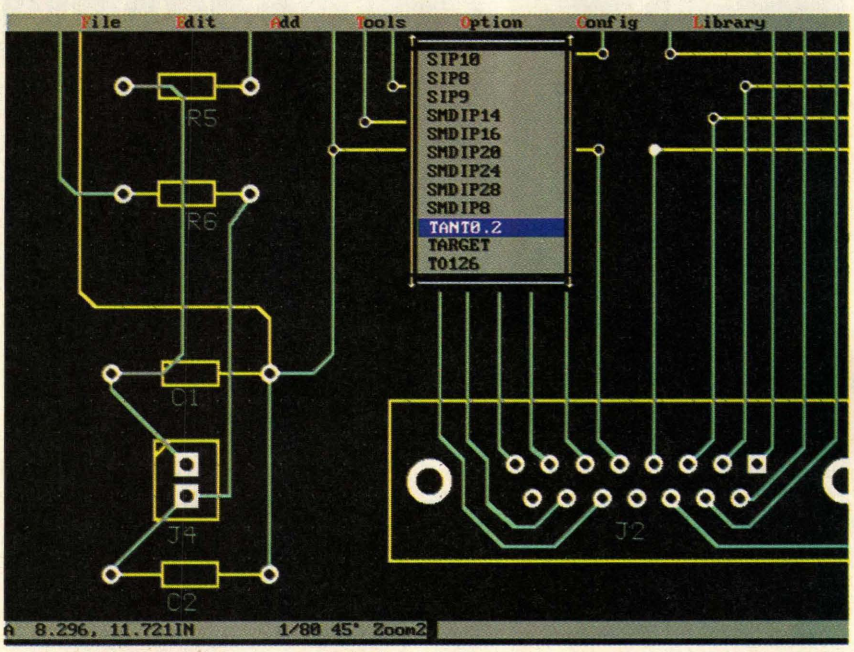


FIG. 7—BOARDMAKER I COMPONENTS are easily accessed from a robust library menu. This is one dynamite program, if you don't mind the working without a net(list).

Epson and LaserJet II compatible printers. In the works, though, is a Gerber and Excellon N/C filer generator.

Circuit Layout is a newcomer to the circuit design arena. The program has been around for only a year, and it has more than a few growing pains. However, the vendor is committed to improving the program and adding companion schematic software to the list of features. This is a serious product that should improve with age.

Product:	TurboCAD for Windows
Version:	2.0
Price:	$129
Platform:	Windows
Publisher:	IMSI

Unlike schematic-capture programs, which require vast libraries of symbols, most drawing programs are easily adapted for use in printed circuit layout. That's because most component outlines and footprints can be constructed using polylines and a handful of circles, squares, and ovals. In fact, several drawing programs, like TurboCAD, come with a library of PC-board footprints. Priced at a low $99 (base price), TurboCAD can be used for a wide variety of drawing projects, like business flowcharting and landscaping, as well as designing boards.

The nice thing about generic drawing programs is that they're more flexible than dedicated circuit design packages. For example, TurboCAD supports 16 drawing layers, which can translate into 16 layers of copper, or a dozen layers of copper and four layers dedicated to silk screen, top and bottom solder masks, and drill layout—or any other combination that suits your needs. Drawing programs are also more likely to have a wider zoom range, more primitives (drawing attributes, like polygons and ellipsis), and greater printer/plotter control. Don't expect support for Gerber or Excellon N/C Drill files, though.

TurboCAD's printed circuit components are contained in an optional $29.95 symbol library (Fig. 6). This library has 11 files, each of which holds a collection of related footprints or pads. For example, TurboCAD's PCB_8 library has 20 resistor footprints, including potentiometers and trimmer potentiometers, and their silkscreen outlines; surface mount pads are found in the PCB_6 library. New symbols are created by binding drawing elements into groups, which are saved as separate files for later import into a new drawing.

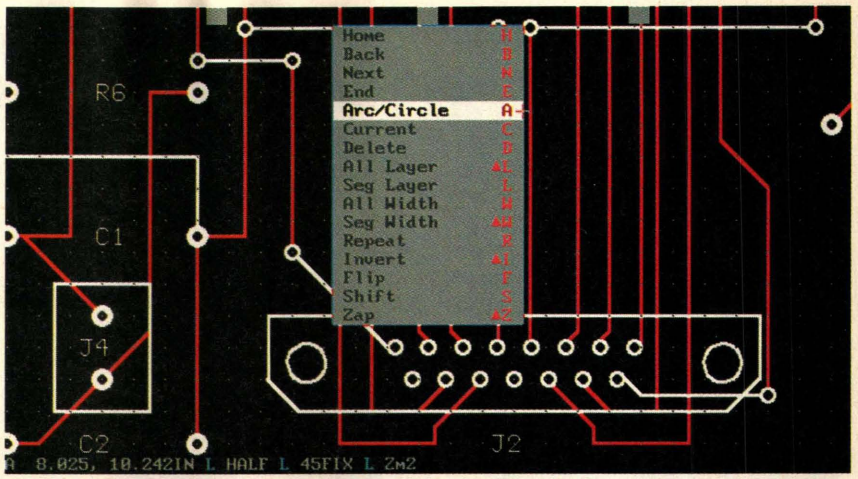


FIG. 8—DESPITE ITS KEYBOARD SHORTCUTS, EASY-PC is comparatively crude, clumsy, and hard to use.

Oddly enough, TurboCAD doesn't have a method for scaling line width to a drawing, which means you can't lay down tracks using the line draw function. As the scale of the drawing changes, so does the line, so that it appears the same width no matter what the magnification factor. Instead, tracks are stored in a library as one-tenth-inch-long segments of assorted widths. A track is formed by placing these segments end to end; 45-degree segments are included to create chamfered corners. Fortunately, the process isn't as tedious as it sounds because once a symbol is selected from a library file, it can be placed repeatedly with a single mouse click. It takes but a few seconds to lay down several inches of track. And changing from one layer to another is just a mouse click away. Unfortunately, TurboCAD doesn't support automatic via placement when changing layers, nor does it support blind vias.

Although a larger assortment of components would be nice (switch and LED footprints are sorely lacking), TurboCAD is extremely easy to use, and well-suited for the task of PC-board layout. However, because it lacks the advanced features you find in most dedicated PC-board layout programs we would recommend it only if you intend to use TurboCAD for other drawing chores when it's not engaged as a PC-board designer.

PC-board Layout with Schematic Draw

These next PC-board layout programs are associated with a schematic capture program reviewed in the September and October 1995 issues of *Electronics Now*. Take note, however, that these programs aren't linked to the schematic capture packages. Instead, they are similar in interface or operation, and are simply bundled together as a convenience and cost saving to the user.

Product:	BoardMaker I
Version:	1.5
Price:	$95
Platform:	DOS
Distributor:	Ohio Automation

BoardMaker I from Tsien (UK) Limited (Ohio Automation is the U.S. distributor) is a DOS-based package that sells for a low $95—schematic draw included. Although the schematic draw and PC-board layout programs aren't linked, as they are in schematic capture/PC-board

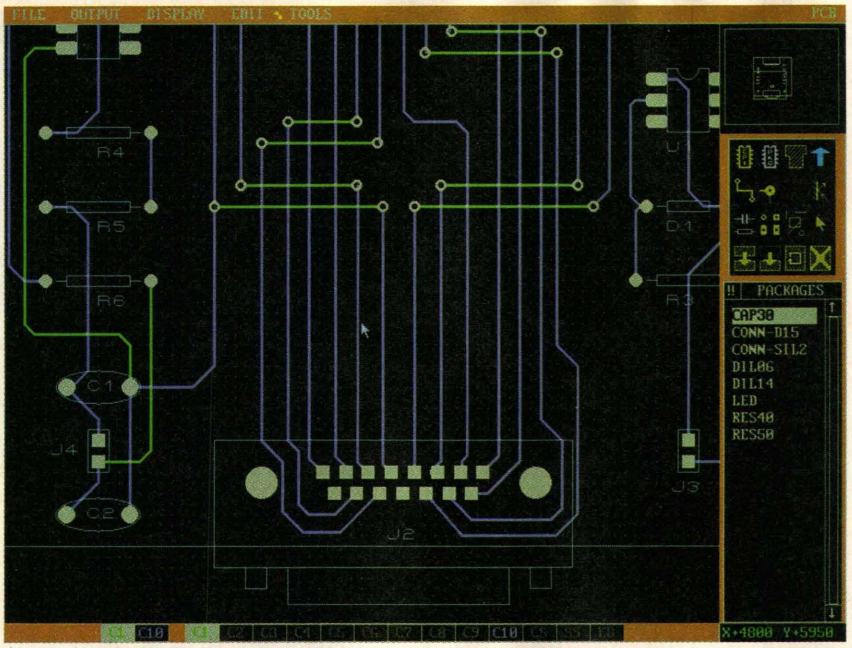


FIG. 9—ONCE YOU GET PAST THE EUROPEAN ICONS, CADPAC II is a very friendly and easy-to-use program. Moreover, the program supports 800-by-600 screens, like the one above, running under DOS, not Windows.

layout software, they are built around the same graphics interface and essentially use the same command structure, which makes the package easy to learn. BoardMaker I is easy to use, too, and can fabricate circuit boards up to 17 by 17 inches, complete with up to eight layers of copper plus two silk screen layers.

Basically, BoardMaker I is a PC-board layout program that supports a library of circuit symbols for schematic draw. However, the schematic draw and PC-board layout programs are independent of each other, and you can run only one at a time. An opening menu lets you choose between schematic draw and PC-board layout. The BoardMaker I PC-board symbol library comes with a total of 99 parts that include a good assortment of through-hole devices, plus a handful of SMD footprints. Despite the seemingly small library part count, it contains everything needed to lay out the benchmark board.

New symbols are created with the Library editor, a stand-alone program that's listed as one of the opening menu choices. Like all BoardMaker I programs, the library editor has the same screen setup and command menus.

The components are easily accessed from a pull-down menu (Fig. 7). PC-board components can be rotated and mirrored after placement. Thankfully, the editing commands are easily accessed from seven pull-down menus, and there's a keyboard shortcut for every command or string. Repeat placement is provided.

Because BoardMaker I doesn't support netlist input, all traces have to be routed by hand. However, BoardMaker I supports layer switching, automatic via placement, and blind vias. You can have eight different track widths per layout, ranging in size from 0.002 inch to 0.531 inch, with 128 widths to choose from. Each design can also have 16 different pad sizes. BoardMaker I comes programmed with 15 popular pad sizes, ranging in diameter from 0.010 inch to 0.302 inch, and the ability to choose from 128 pad sizes and styles.

Output can be sent to dot-matrix, LaserJet, and PostScript printers, plus HPGL and DMPL penplotters. Gerber and N/C Drill files are also supported.

This program is extremely easy to learn and use. The ability to zoom and pan during placement and editing—two very powerful features you wouldn't expect in a program costing so little—make working with this software a real pleasure. BoardMaker I definitely rates two-thumbs-up.

Product:	Easy-PC
Version:	I0142
Price:	$145
Platform:	DOS
Distributor:	BSOFT Software, Ohio Automation

Before there was BoardMaker I, the low-cost leader was Easy-PC—the precursor to BoardMaker I. These programs were written by the same person, and in many respects the two are alike. For example, Easy-PC is a DOS-based PC-board layout program with two separate symbol libraries, one for schematic symbols and another for PC-board component footprints and pads. Easy-PC supports up to eight copper layers on boards as large as 17-inches square, there are 128 track widths and pad sizes to choose from, different track widths and pad sizes can be mixed in a design, and the program supports blind vias. The nearly-dual identity is reinforced by the interface, which has the same basic look and feel of BoardMaker I. Yet despite the overwhelming similarities, the two are far from being twins. The first clue is the price: BoardMaker I costs $95, while Easy-PC costs $145—$50 more than BoardMaker I, the upgrade version.

A bigger difference, though, is in the way you perform operations. Compared to most layout programs, Easy-PC's command structure is crude, clumsy, and hard to use (Fig. 8). For example, to place or edit a part, you need to click on a button in the upper left corner. That would be simple enough—if the button were labeled. It isn't, and there are no menu illustrations or tables in the manual that shows what the button does.

Once the menu is open, you are presented with a list of options that lets you place and edit tracks, pads, parts, and text. To place a part, though, you need

to know its exact name as listed in the Appendix of the User's manual. Unlike BoardMaker I, there is no library menu—an oversight that eventually forced us to post the symbol reference chart on a nearby wall. Easy-PC's PC-board layout library comes with 52 symbols (BoardMaker I has 99), which includes a good assortment of connectors, DIPs, SMD, and transistor footprints. New symbols can be created from scratch or by editing existing symbols using a separate library editor program. But you have to quit what you're doing, because only one Easy-PC program can run at a time. Thankfully, the library editor is easier to use than the program itself, because we had to create two devices to build the *Electronics Now* benchmark, and there are no resistor or capacitor footprints. While the library can hold only 100 patterns, there is no limit to the number of libraries you can have. There is a catch: All the symbols for a layout must come from the same library.

Laying down tracks is fairly straightforward, but the fact that you can't see the trace until you click on the endpoints is a real hindrance. Automatic vias are supported, and you can change layers on the fly. All of the menu commands have a keyboard equivalent, which speeds up the drawing process.

Printer and file output is good, with support for dot-matrix, LaserJet, and HPGL printers and plotters. Besides printing individual copper layers, Easy-PC prints top and bottom silk screens, drilling pattern, and solder masks. Also included are utilities that generate Gerber files, N/C Drill, and Photoplotter files, which are used by service bureaus to produce finished PC boards.

When choosing between Easy-PC and BoardMaker I, you have to consider the entire package—both schematic draw and PC-board layout. For schematic draw, Easy-PC wins with a larger component library and the ability to upgrade to Easy-PC Pro, a fully-featured schematic capture and PC-board layout program. If PC-board layout is a high priority, BoardMaker I wins because it has a larger symbol library and is easier to use.

Product:	CADPAC II PCB II
Version:	2.54
Price:	$159
Platform:	DOS
Publisher:	R4 Systems Inc.

CADPAC II's PC-board layout program is PCB II, made by Labcenter Electronics and distributed by R4 Systems Inc., of Canada. Its companion schematic draw program is ISIS Supersketch, which was reviewed in the September 1995 issue of *Electronics Now*. When sold together, this dynamic duo costs $159—only $10 more than the base version of PC-board II.

PCB II is a DOS-based, entry-level program that can be used to design double-sided boards up to 30-inches square. Once learned, the program is very easy to use, but the learning curve is steeper than most. It's not any worse than a high-end program like Tango, but its European icons and British terminology take a bit of getting used to (Fig. 9). Fortunately, both the schematic draw and PC-board layout programs have the same graphical interface, so you only have to learn it once.

PCB II has almost 300 outlines and footprints stored in three library modules. Over 100 patterns are for general purpose use and the remaining 160 or so are dedicated for surface mounted devices. These two libraries are more or less divided in half, with one containing SMT foot prints for SMD chips, and the other with two-terminal components. There's also an empty module that can be used as a staging area for the assembly of new libraries.

The fastest way to lay out a printed-circuit board using PCB II is to make a list of the components needed, then select them from the appropriate library module, which transfers them in a "shopping" list located on the right side of the screen. Parts are placed on the screen by highlighting a symbol name from the shopping list and clicking on its desired loca-

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WHERE TO BUY

BoardMaker I
Ohio Automation
7840 Angel Ridge Rd.
Athens, OH 45701
(614) 592-1810

CADPAC II
R4 Systems Inc.
1100 Gorman St.
Suite 11B-332
Newmarket, Ontario, Canada L3Y 7V1
(905) 898-0665

Circuit Layout
PC Logic
11 Brook Hollow
Pittsford, NY 14534
(716) 248-9800

DC/CAD
Design Computation
1771 State Highway 34
Farmingdale, NJ 07727
(908) 681-7700

Easy-PC
Easy-PC Pro
BSoft Software, Inc.
444 Colton Rd.
Columbus, OH 43207
(614) 491-0832

Easytrax
Protel Technology, Inc.
2675 Stevens Creek Blvd.
Santa Clara, CA 95051
(408) 243-8143
ftp://protel.com/http/protel/dostools/easytrax.zip

EZ-Route Std
Advanced Microcomputer Systems, Inc.
1460 SW 3rd St.
Pompano Beach, FL 33069
(800) 972-3733

PCAD
Micronics Technology
7709 Skylake Dr.
Fort Worth, TX 76179
(817) 236-5049

PCBoards
PCBoards
2110 14th Ave. South
Birmingham, AL 35205
(800) 473-7227

SuperPC-board for Windows
Mental Automation Inc.
5415 136th Place S.E.
Bellevue, WA 98006
(206) 641-2141

TurboCAD
IMSI
1938 Fourth St.
San Rafael, CA 94901
(415) 454-7101

bers specify both the desired extension and the ring pattern to use. So to call Station 1, dial any local or long distance number, but substitute for the last two digits the desired extension code (10–19). Refer to Table 1 for the extension number assignments and Table 2 for the ring patterns.

Note that Extensions 00 and 70–99 do not exist, and will always result in a busy signal. Those values can be used to test devices, such as fax machines and modems, that detect busy conditions.

You can also dial a station using just the two-digit extension. Just press the "#" key followed by the two digit extension number. For example, "#50" will ring Station 5 with Type 1 ring pattern. The quick-dial method is perfect for the intercom application, because fewer digits must be dialed.

Calling all stations

You can ring all stations simultaneously by dialing "#0" from any station. To prevent excessive ring current, Stations 1–3 and 4–6 ring in an alternating pattern. The ring pattern follows the industry-standard pattern of a two second ring followed by a four-second silence.

Dial tone silence and recall

Whenever you take a phone off-hook, you immediately receive a dial tone. You can temporarily disable the dial tone by dialing "##". Hanging up restores normal dial-tone operation.

Whenever you begin a new dial sequence with "*" followed by two digits (00–99), you will hear three short beeps followed by the dial tone. That tone pattern is known as Recall Dial Tone, and is used by the phone company, as well as other phone systems, to indicate that special features are in effect. Party Line uses three recall dial patterns (*67, *61, and *60) for Caller-ID related features. The remaining recall dial patterns are unused. Before we discuss the actual Caller-ID features, we'll provide some background on what Caller-ID is and how it works.

TABLE 2—EXTENSIONS AND RING PATTERNS

Extension	Ring Pattern	Remarks
10, 14-19	Normal	Station 1, Normal Ring
11	Long-Long	Station 1, Type 1 Ring
12	Short-Short-Long	Station 1, Type 2 Ring
13	Short-Long-Short	Station 1, Type 3 Ring
. . .	. . .	. . .
60, 64-69	Normal	Station 6, Normal Ring
61	Long-Long	Station 6, Type 1 Ring
62	Short-Short-Long	Station 6, Type 2 Ring
63	Short-Long-Short	Station 6, Type 3 Ring

Caller-ID

In case you're not familiar with Caller-ID (CID), it is a popular service provided by the phone company that allows you—before answering your phone—to see the telephone number of the person who is calling you. CID relies on a special 1200-Baud FSK (frequency-shift keying) audio broadcast that occurs between the first and second rings on your phone line. It is a one-way transmission and is sent as a Bell 202 type signal. (If you're interested in the technical details, technical specification number TA-NWT-000030 can be obtained through BELLCORE Customer Services, 60 New England Ave., Piscataway, NJ 08854-4196. (908) 699-5800.)

Until recently, many areas offered only the single-message format, which provides the caller's directory number, the time, and the date. A more advanced version uses a multiple message scheme that also includes the name of the caller. Because your phone company provides CID as a custom service, you must pay a small monthly fee to be able to receive it. A special box, which plugs directly into the telephone line, receives and displays the transmission.

CID is widely available in the U.S. and some other countries, including Canada, Australia, and Israel. Unfortunately, not all areas in the U.S. support CID, and several states have prohibited it because they view it as an invasion of privacy. In addition, some foreign countries have adopted incompatible formats. None of those issues affect Party Line operation, because it does not connect to the public switched network. In other words, you can freely use Party Line's CID features, even if CID is not available in your area. Party Line should function with any off-the-shelf CID display, some of which are available for as little as $25. If you want to use the name-delivery mode, be sure to obtain a compatible unit. (A jumper on the Party Line's PC board enables and disables name-delivery mode.)

The phone number that Party Line transmits in CID format is the same as the phone number used to make the call. For example, if you dial 1-916-985-7219, Station 1 will ring, and the attached Caller-ID box will show that number, along with the date and time and a calling-party name.

TABLE 1—EXTENSION NUMBER ASSIGNMENTS

Station	Extension Range	Remarks
1	10–19	
2	20–29	
3	30–39	
4	40–49	
5	50–59	
6	60–69	
None	09–01,70–99	Not used, always busy

As for the time and date information, Party Line includes a software-based clock. We included the time function so that you can experiment with your Caller-ID products. However, the clock is not designed as a precision timepiece. It may gain or lose a few seconds each day, and the date function must be manually updated every day. (You can set the time and date from the keypad of any attached phone.)

Obviously, the Party Line cannot display real calling-party names. Instead, if your CID display functions in the name and number delivery mode, you'll see one of six stored names, as shown in Table 3, depending on which station made the call. If you dialed using Quick Dial mode, the names shown in Table 3 are not used. Instead, Party Line transmits a message of the form, "STATION X", where X is a number from 1–6 that represents the calling station. That format is perfect for use in the personal-intercom application.

CID Features

Party Line supports three CID-related features: number block, out-of-area, and corrupt checksum. Number block allows the calling party to prevent transmission of his or her name and number information to the receiving station. Activate number block by dialing "*67" before the local or long-distance number. Your CID display will then show a message such as "Number Blocked" or "Private." As with all recall-dial features, the *67 code must be repeated for each call, and may be canceled by hanging up.

The second feature simulates calling from outside your local calling area. When you receive such a call via the public switched network, your CID display will show "Out-of-Area," "Number Unknown," or something similar. Activate the out-of-area feature by dialing "*61" before the target number.

Party Line's third CID-related feature allows you to simulate Caller-ID broadcast errors. This feature allows hardware and software developers to test Caller-ID products under simulated noisy line conditions.

The way it works is that a special checksum value is sent with each CID message to help check for errors. Since an incorrect checksum indicates that the delivered message is defective, we can simulate transmission errors simply by deliberately altering the checksum value. To use the corrupt checksum feature, dial "*60" before your local or long distance number. Your CID display box will show an error message or remain blank.

TABLE 3—CALLER-ID NAMES

Station	Name
1	YOUR NAME HERE
2	MOTHER IN LAW
3	JOHN SMITH JR.
4	ROSIE PORTER
5	ACME COMPUTERS
6	ABBY THOMPSON

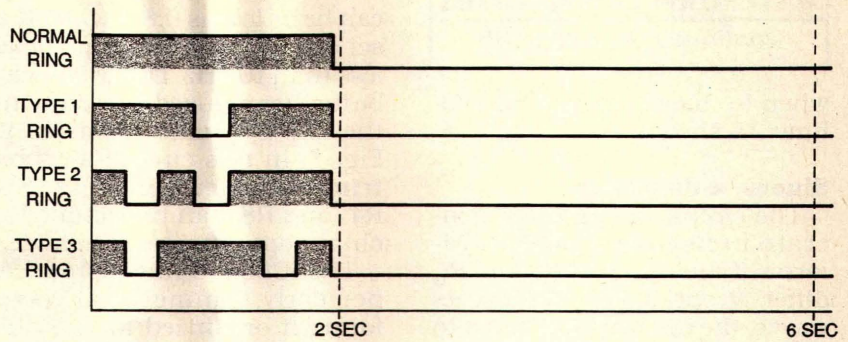

FIG. 1—DISTINCTIVE RING TIMING: Regardless of the ring type, the period of the cycle is six seconds, the last four of which are quiet. Only the ring formats during the first two seconds vary.

Distinctive ringing

North American readers are familiar with the standard two-on four-off ring pattern. (Other countries use other patterns for their standard ring.) In the past few years, phone companies have started offering new services that depend on different ring patterns. With Party Line you can use and test equipment that responds to distinctive ring patterns.

Not all phone companies call it distinctive ringing. We've seen terms such as Custom Ringing, IdentaRing, RingMaster, Multi-Ring, RingMate, SmartRing, Ident-a-Call, Personalized Ring, and others.

Whatever you call it, Distinctive Ringing (DR) allows one physical phone line to respond to two or more different telephone numbers. The catch is that only one number can be active at a time. Nonetheless, DR can be useful for small businesses that want to publish different numbers for voice, fax, and modem, or for households in which teenagers or other family members want separate numbers. The cost of adding DR should be less than adding additional physical lines. With DR active on a line, each dialed number produces a different ringing pattern.

The full ring cycle length is still six seconds, and the four-second silence remains the same. Only what happens during the two-second ring time varies. As shown in Fig. 1, there are three distinctive ring patterns:

Type 1: Long-Long
Type 2: Short-Short-Long
Type 3: Short-Long-Short

Some recent telephone products perform different actions depending on the ring type received. For example, some fax machines automatically use the feature to switch between voice and fax modes. As described earlier, Party Line's DR feature is controlled by the second digit of the two-digit extension number. See Table 2.

How it works

Figure 2 shows a block di-

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when R_T has a value of 82 kilohms, as shown.

Sinewave distortion

The circuit in Fig. 5 will generate nonsymmetrical waveforms if the values of R_A and R_B differ. To obtain the purest sinewaves, the circuit must be set to provide waveform symmetry. Figure 6 is a modification of Fig. 5 showing how fixed trimming resistor R_T is replaced by a trimmer potentiometer so that the sinewaves can be adjusted for minimum distortion.

This distortion of this circuit can be as low as 0.8% when it is set to produce fixed frequencies less than 10 kHz. Distortion can be further reduced by modifying the Fig. 6 circuit as shown in Fig. 7. In this circuit, all three trimmer potentiometers, R3, R4, and R8, can be trimmed to obtain optimum performance.

The ICL8038 rarely produces perfectly symmetrical waveforms if organized for variable frequency output applications. Distortion can be 2 % or more. It should also be pointed out that the IC tends to run warm. It draws a quiescent current of about 12 milliamperes at 20 volts.

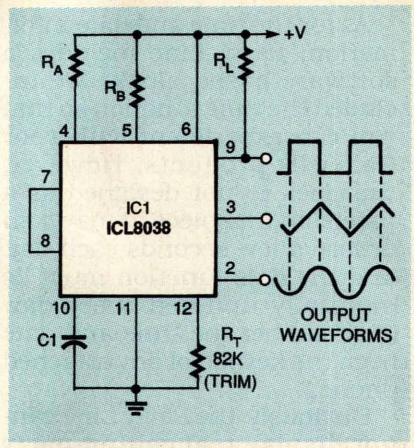


FIG. 5—FIXED-FREQUENCY triangle/sine/squarewave generator.

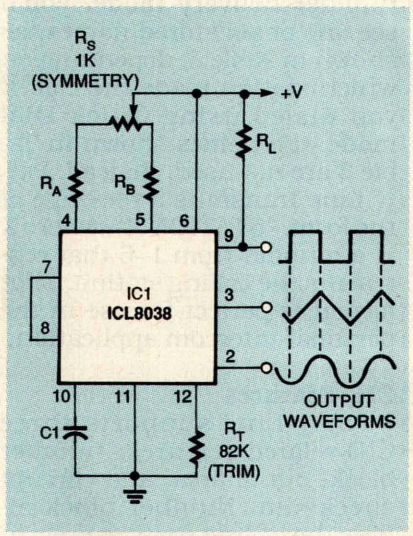


FIG. 6—MODIFIED FIXED-FREQUENCY triangle/sine/squarewave generator.

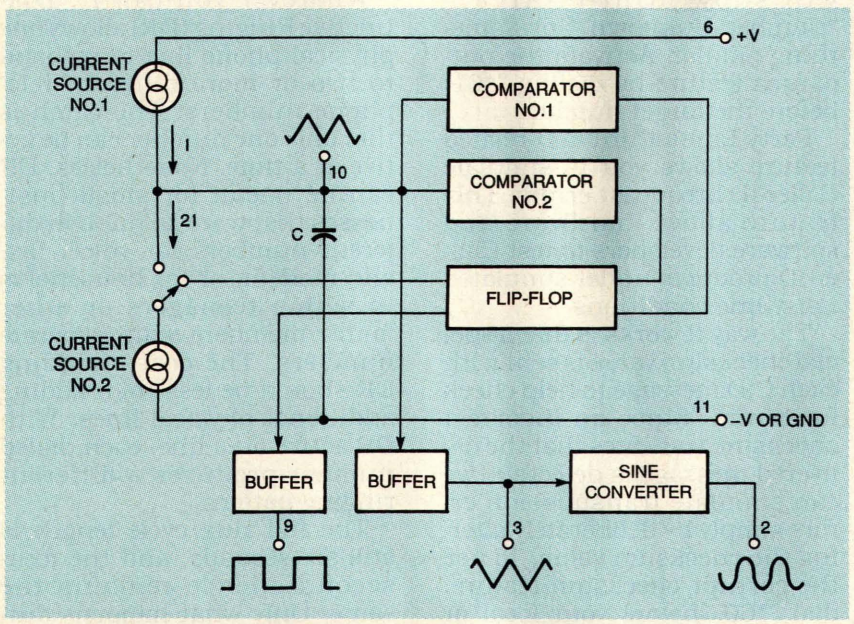


FIG. 3—A FUNCTIONAL DIAGRAM for the Harris ICL8038 waveform generator.

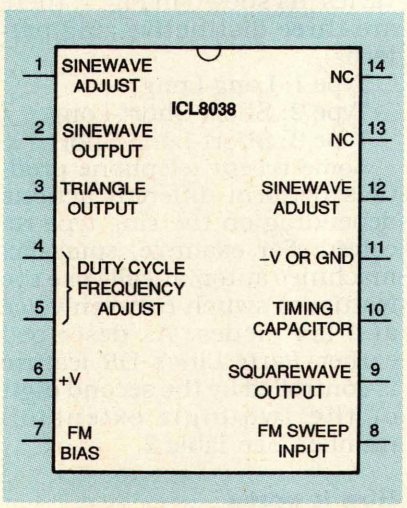


FIG. 4—PIN CONFIGURATION for the Harris ICL8038 waveform generator.

Dual power supplies

The circuits shown in Figs. 5, 6, and 7 are all powered by positive or single-ended power supplies. The three output waveforms all swing about (or are centered on) the value equal to half the supply voltage. However, the circuits can all be powered by dual (positive and negative) power supplies. In those cases, the output waveforms will be centered on the ground bus of the dual supply.

Remember that regardless of the form of the power supply, FM SWEEP INPUT pin 8 is susceptible to unwanted signal noise and hum. The pin should be decoupled with a 0.1 μF capacitor between pin 8 and the +v pin 6.

The operating frequency of the ICL8038 is directly related to the DC voltage applied between pins 6 and 8. As a result, frequency can be varied or swept by changing this voltage. The frequency can also be modulated by feeding a signal to pin 8. The circuit in Fig. 8, which includes an ICL8083, will function as a manually-controlled, variable-frequency waveform generator. Pin 8 is connected to the wiper of potentiometer R1 so that the voltage can be varied from two-thirds of the supply voltage to its maximum value.

The lowest frequency is obtained when the voltage at pin 8 equals the supply voltage, and the highest frequency is obtained when the potentiometer wiper is set at two-thirds of the

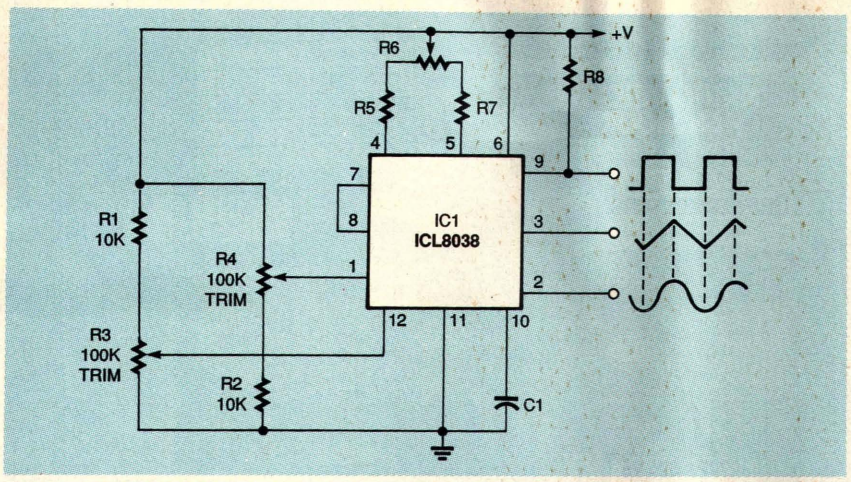


FIG. 7—SQUAREWAVE GENERATOR modified to minimize sinewave distortion.

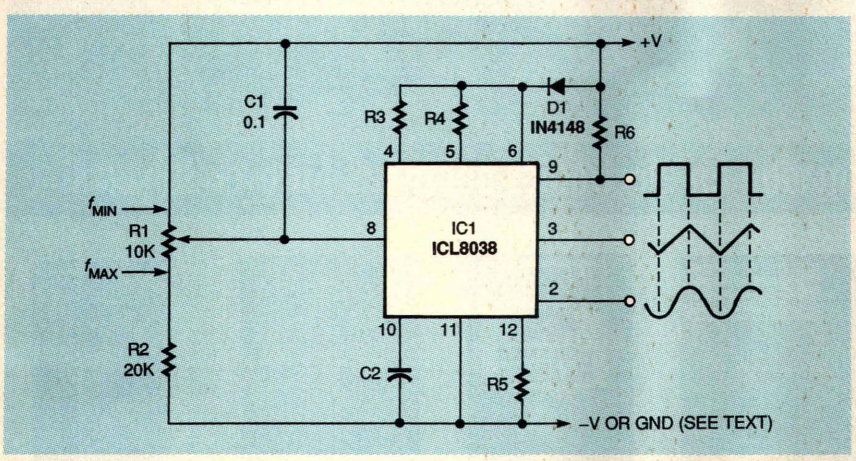


FIG. 8—WIDE-RANGE, VARIABLE-FREQUENCY waveform generator.

to 100 kHz) sine/triangle/squarewave generator formed by combining the circuits in Figs. 7 and 8 and adding an operational-amplifier buffer. To set up this circuit, set potentiometer R4 to its midrange and switch S1 to range 2. Then trim potentiometers R1 and R3 so that the generator can cover the 100-Hz to 10-kHz frequency range by adjusting potentiometer R2.

Next, set potentiometer R2 to give a 1-kHz output, and trim R4 to give a symmetrical squarewave output. Measure the frequency range, and then reset 1 kHz and trim potentiometers R9 and R12 for minimum sinewave distortion. Table 1 gives the frequency ranges that can be obtained from each of the four channel positions of switch S1.

Exar XR-2206

The XR-2206 is an integrated circuit function generator capable of producing stable and accurate sine, square, ramp and pulse waveforms. The output waveforms can be both amplitude and frequency modulated by an external voltage. They can also be frequency-shift

Table 1—Switch Position vs. Frequency

Switch 1 Channel	Frequency range (Nominal)
1	10 Hz to 100 Hz
2	100 Hz to 1 kHz
3	1 kHz to 10 kHz
4	10 kHz to 100 kHz

supply voltage plus 2 volts. This circuit can be varied in frequency over a range of about one thousand to one.

To obtain this range, the highest control voltage on pin 8 must exceed that on pin 6 by a few hundred millivolts. This is achieved by reducing the voltage on pin 6 to about 600 millivolts below the supply voltage with the forward drop of diode D1. However, for optimum frequency stability, both of the circuit's supply voltages must be regulated.

Figure 9 is a wideband (10 Hz

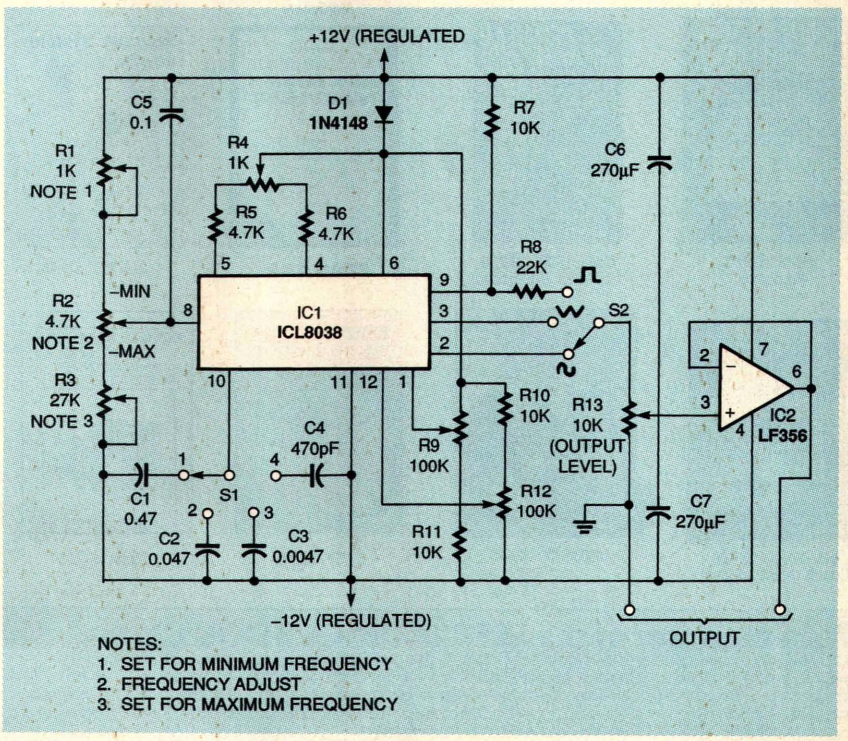
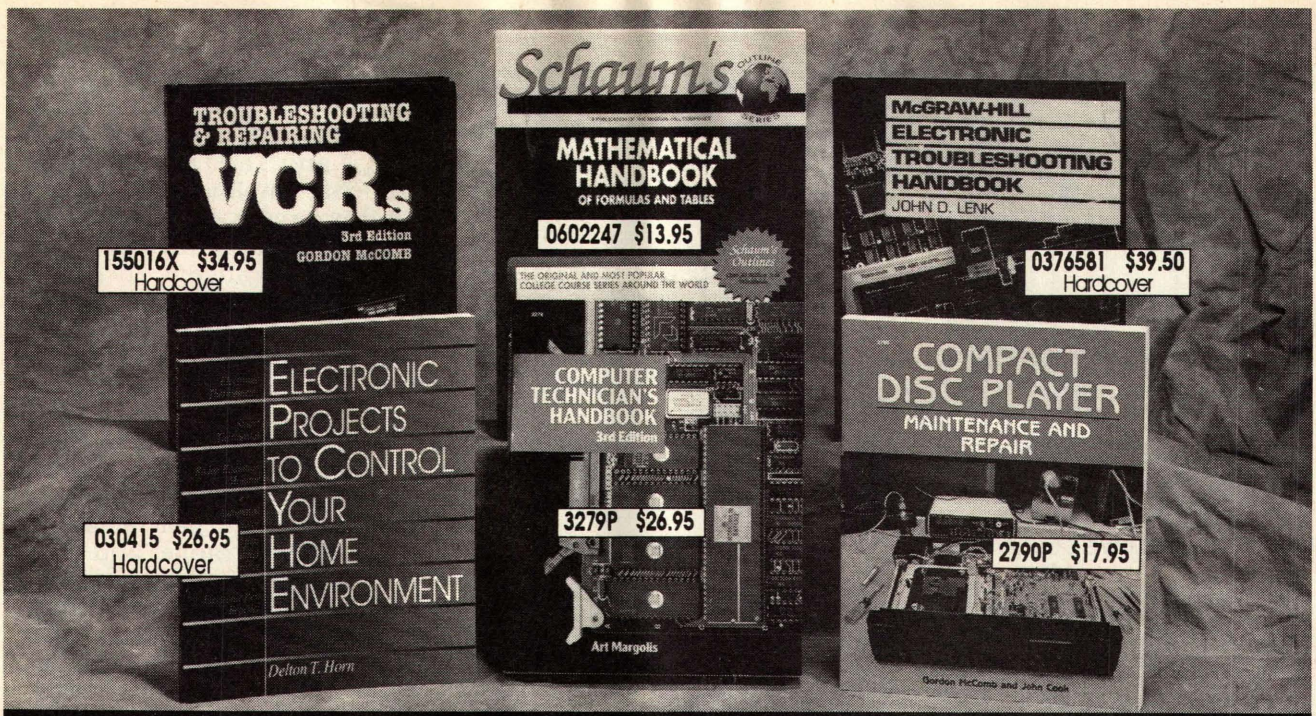


FIG. 9—WIDE-RANGE, VARIABLE-FREQUENCY waveform generator with a dual power supply.



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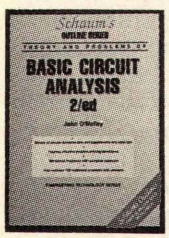

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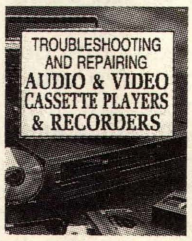

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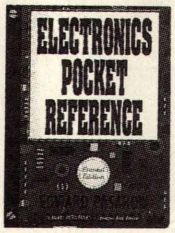

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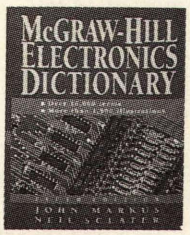

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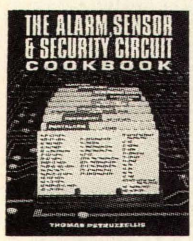

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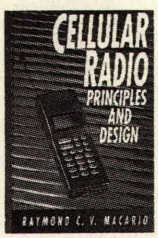

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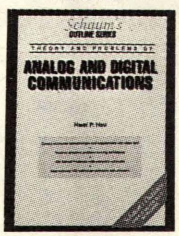

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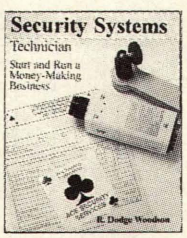

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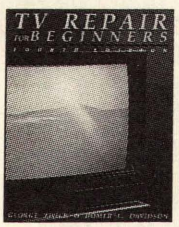

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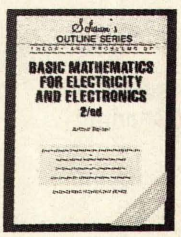

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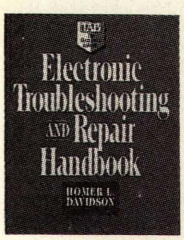

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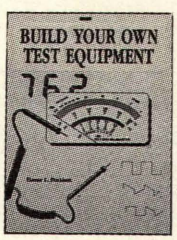

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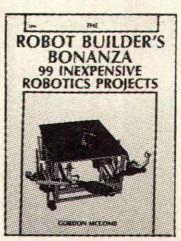

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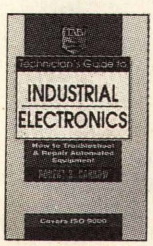

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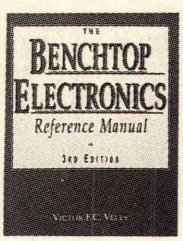

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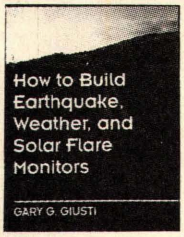

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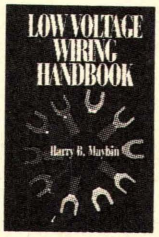

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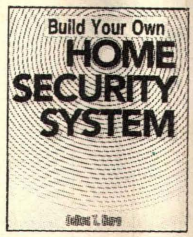

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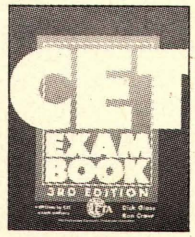

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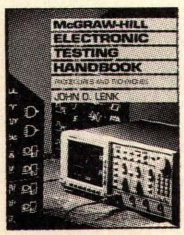

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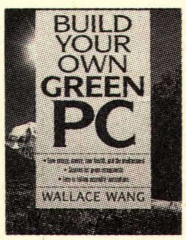

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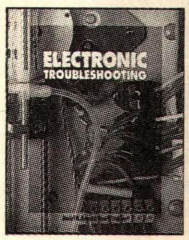

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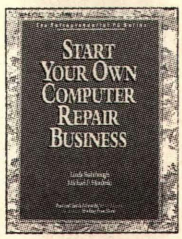

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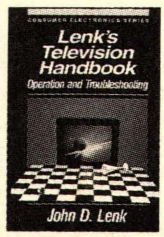

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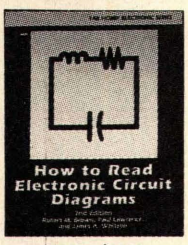

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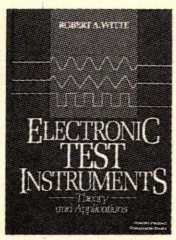

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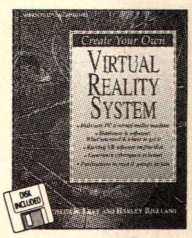

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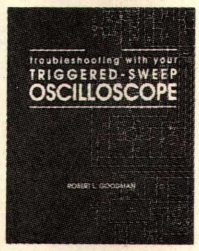

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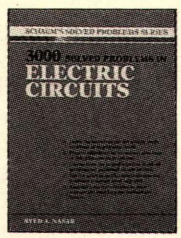

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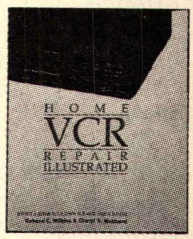

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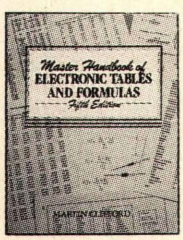

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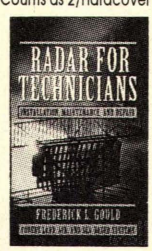

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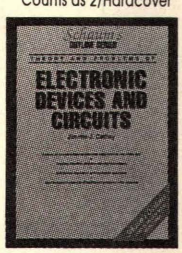

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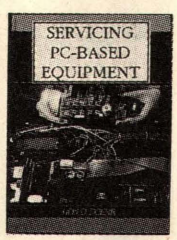

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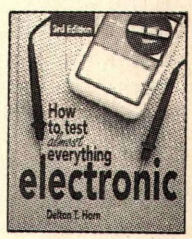

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key (FSK) modulated. The IC's operating frequency can be selected externally over a range of 0.01 Hz to more than 1 MHz.

Figure 10 is a functional diagram of the XR-2206 combined with its pinout arrangement diagram. The device includes four functional blocks: a voltage-controlled oscillator (VCO), an analog multiplier and sine shaper, and a set of current switches. It can be powered by either a single or dual power supply.

The VCO produces an output frequency that is proportional to an input current. That current flows in a resistor from the timing terminal to ground. The current switches route current from one of the timing pins to the VCO controlled by a frequency-shift keying (FSK) input pin to produce an output frequency. With two timing pins, two discrete output frequencies can be independently produced for FSK generation applications.

Figure 11 is a function generator circuit that includes an XR-2206 powered by a single power supply. Its operating frequency is inversely proportional to the values of C1 and the combined resistance of resistor R1 and potentiometer R7 in series. Frequency can be varied from 10 Hz to 100 kHz in four decade ranges with the capacitor values given in Table 2. The amplitude of the sine/triangle output can be varied with output-level potentiometer R8, but it can have its maximum value preset by level-control potentiometer R6. The sinewave distortion of this circuit is typically less than 2.5%.

Figure 12 is a modified version of the Fig. 11 circuit that operates from a dual power supply. It is designed to reduce sinewave distortion to about 0.5 % by the adjustment of symmetry potentiometer R3 and distortion-control potentiometer R5. These two controls must be adjusted in unison after the circuit is built, but they need not be adjusted again. The maximum output level of these circuits can be preset by potentiometer R1. It should be set to give a maximum output of less than 2 volts RMS to prevent excessive distortion. Table 2 lists the frequency range of this circuit for each value of capacitor C1, as in Fig. 11.

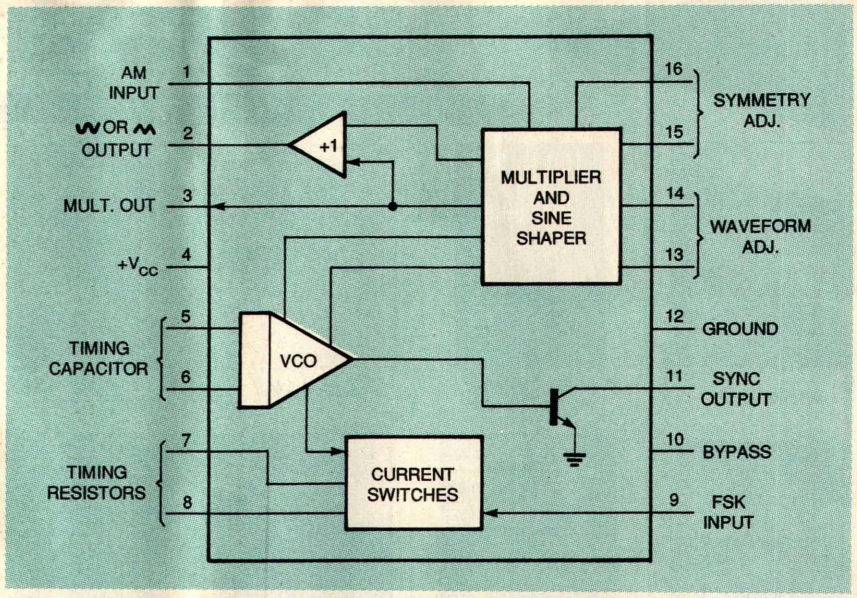

FIG. 10—FUNCTIONAL BLOCK DIAGRAM for the Exar XR-2206 sine/triangle/square-wave generator.

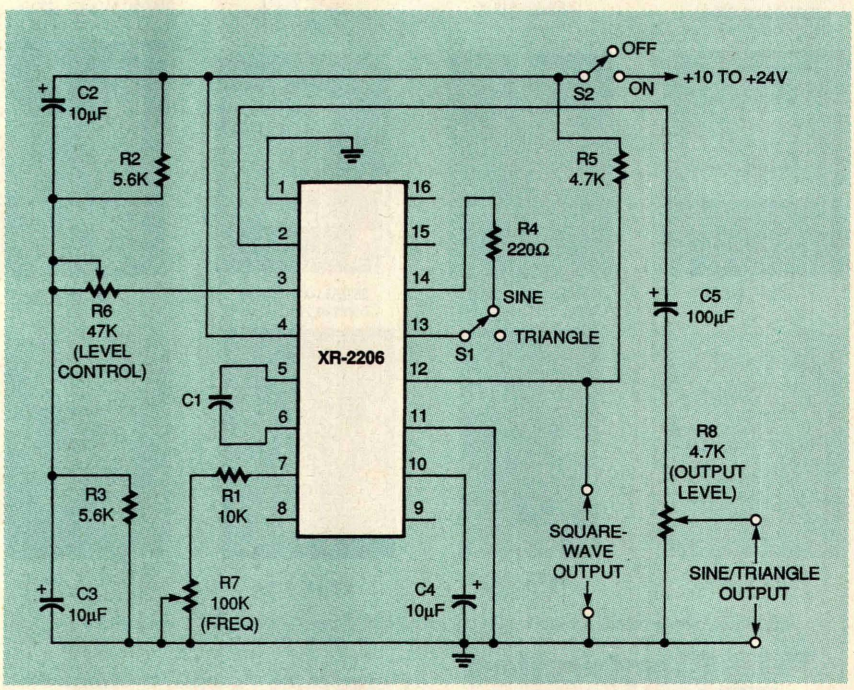

FIG. 11—SINE/TRIANGLE/SQUAREWAVE generator based on the XR-2206.

Table 2—Capacitor Values vs. Frequency

Capacitor C1	Frequency range (Nominal)
1 µF	10 Hz to 100 Hz
0.1 µF	100 Hz to 1 kHz
0.01 µF	1 kHz to 10 kHz
0.001 µF	10 kHz to 100 kHz

LC oscillators

The last article in this series discussed the Wien-bridge and twin-T oscillators. Both included resistive-capacitive (RC) tuning networks whose output was limited to several hundred kHz. By contrast, oscillators that include inductive-capacitive (LC) tuning circuits can generate signals from tens of

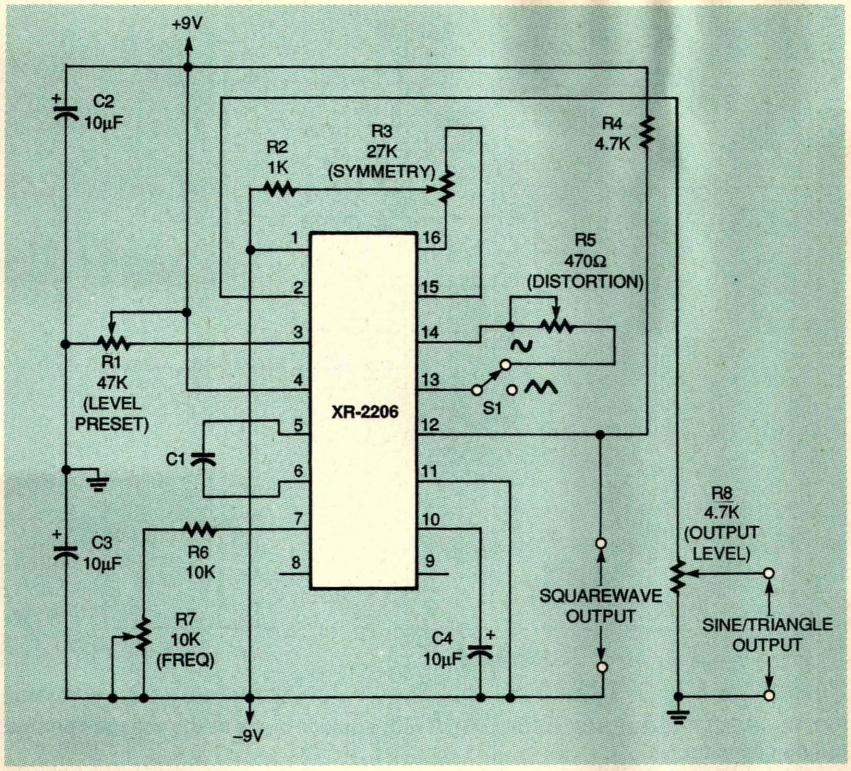

FIG. 12—SINE/TRIANGLE/SQUAREWAVE generator based on the XR-2206 with a dual power supply.

kHz to hundreds of MHz.

A transistorized LC oscillator includes a transistor amplifier and a frequency-selective LC network that provides feedback in accordance with the Barkhausen criteria. Inductive-capacitive networks have inherently high Q or frequency selectivity. Oscillators in this class produce reasonably pure sinewaves, even if the oscillator's loop gain is far greater than unity.

Among the many LC transistor oscillators are the tuned-collector, Hartley, Colpitts, Clapp, and Reinartz oscillators. Figure 13 is a schematic for a tuned-collector oscillator. In this schematic, the base bias for transistor amplifier Q1 is provided by resistors R1 and R2, and resistor R3 that is decoupled by capacitor C2.

The tuned-collector circuit is formed by L1-C1, and the collector-to-base feedback is provided by coil L2 of transformer T1, which is inductively coupled to coil L1. By selecting the phase of this feedback signal, the circuit can give zero-loop phase shift at the tuned frequency. Consequently, if loop gain (determined by the turns ratio of T1) is greater than unity, the circuit will oscillate.

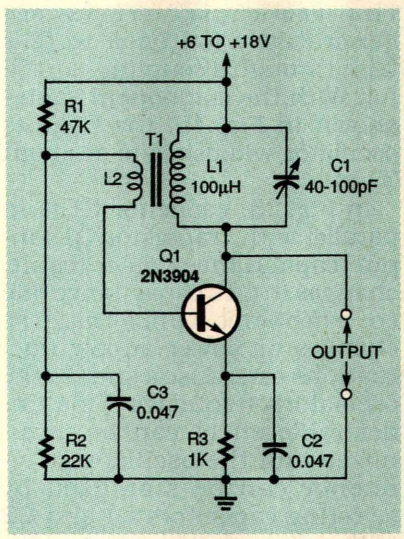

FIG. 13—TUNED-COLLECTOR inductive-capacitive oscillator.

The phase relationship between the energizing current and induced voltage of all LC oscillators varies between −90° and +90°. It is zero at the center frequency (f) determined by $f = 1/2\pi\sqrt{LC}$. The overall phase shift of the circuit in Fig. 13 is zero, and the circuit oscillates at this center frequency.

If a tuned-collector oscillator has the component values given in Fig. 13, its center frequency can be varied from 1 MHz to 2 MHz by variable capacitor C1. However, the circuit can easily be modified to operate at frequencies ranging from tens of Hz (with a laminated-iron-core transformer) up to hundreds of MHz.

Hartley, Colpitts, and Clapp

The best-known LC oscillators are the Hartley and Colpitts oscillators, widely used in radio-frequency applications. The Hartley oscillator, as shown in Fig. 14, is a variation of the tuned-collector oscillator shown in Fig. 13. Its frequency-determining resonant tank contains a tapped coil. The collector and base are at the opposite ends of the tuned circuit to provide a 180° phase shift. Feedback occurs through mutual inductance between the two parts of the coil.

In Fig 14, the collector load coil L1 is tapped at a point 20 % along its overall length, and that tap is connected to the oscillator's positive power supply. Inductor L1 acts as an autotransformer, so the signal voltage that appears at the top of L1 is 180° out-of-phase with the signal voltage at its lower (collector Q1) end. The phase of the

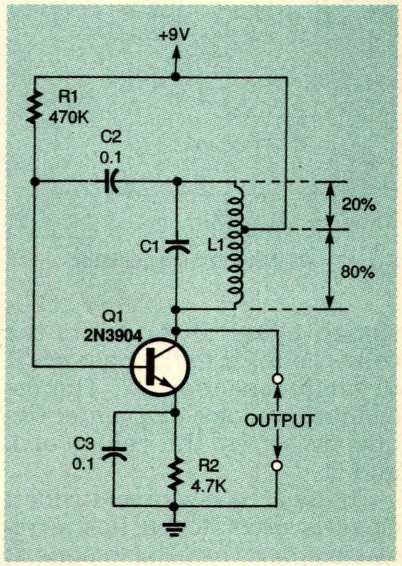

FIG. 14—HARTLEY TUNED-COIL inductive-capacitive oscillator.

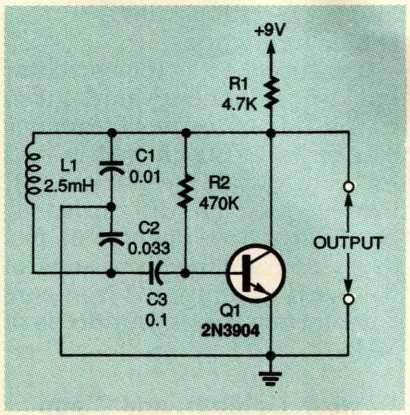

FIG. 15—COLPITTS TUNED-CAPACITOR oscillator.

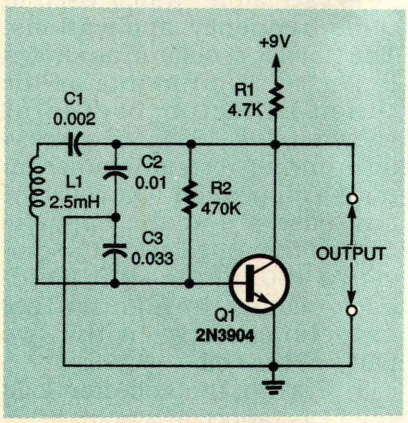

FIG. 16—CLAPP (MODIFIED COLPITTS) LC oscillator.

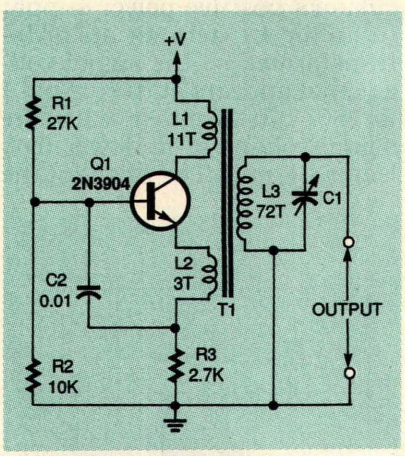

FIG. 17—REINARTZ LC oscillator.

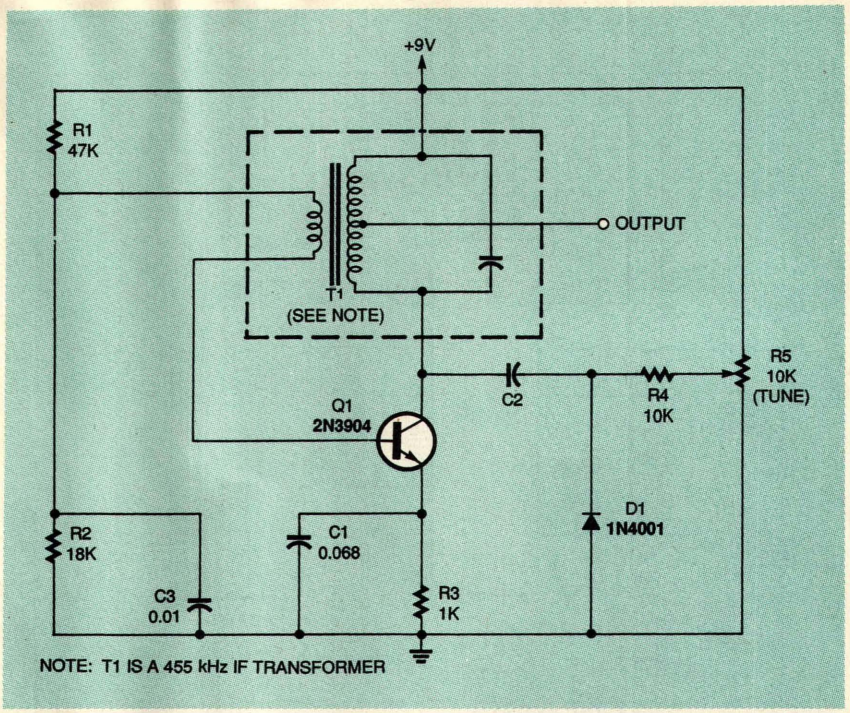

FIG. 18—BEAT-FREQUENCY OSCILLATOR with a silicon diode as the voltage-variable tuning capacitor.

signal voltage at the top of the coil is coupled to the base of Q1 through capacitor C2. The oscillator oscillates at a center frequency set by the values of L and C.

Figure 15 is a schematic for a Colpitts oscillator. It has a frequency-determining resonant tank circuit that includes a capacitive voltage divider. A fraction of the current flowing in the tank circuit is regeneratively fed back to Q1's base through a coupling capacitor. With the component values shown in Fig. 15, the Colpitts oscillator will oscillate at about 37 kHz.

In Fig. 15, capacitor C1 is in parallel with transistor Q1's input capacitance. As a result, changes in Q1's capacitance due to ambient temperature changes or power supply fluctuations can cause a shift in the oscillator's frequency. This undesirable effect can be minimized and the oscillator's frequency can be stabilized by selecting capacitors C1 and C2 with values that are large with respect to transistor Q1's internal capacitance.

Figure 16 is a schematic for a Clapp oscillator, a modification of the Colpitts oscillator. Its resonant circuit contains a small-value capacitor added in series with the resonant tank coil. The values of that capacitor and the tank coil determine the oscillator's frequency. This modification minimizes the effects of amplifier capacitance on the output frequency.

In this circuit, capacitor C3 is in series with L1, and its value is small with respect to the values of capacitors C1 and C2. Consequently, the circuit's resonant frequency is determined principally by the L1 and C3 values, and it is not disturbed by variations in the capacitance of transistor Q1. A Clapp oscillator circuit with the component values shown in Fig. 16 will oscillate at about 80 kHz.

Reinartz and cap tuning

Figure 17 is the schematic for a Reinartz oscillator. Regenerative feedback occurs between the collector and emitter of a common-base amplifier transistor Q1. Its frequency is determined by the values of the LC resonant tank circuit, which is inductively coupled to the collector and emitter coils.

The Reinartz oscillator oscillates at a frequency set by the turns ratio of the primary and secondary coils of transformer T1. Figure 17 shows typical transformer turns ratios for oscillation at several hundred kHz. Reinartz oscillators can generate sinewave frequencies up to the UHF region.

Figure 18 is a schematic

continued from page 149

continued from page 28

GLOSSARY OF SELECTED COMPUTER TERMS

10Base2—Ethernet local area network using thin coaxial cable wiring. Also called cheapernet and thinnet.
10BaseT—Ethernet local area network using twisted-pair wiring.
Adapter card—A peripheral, such as a modem, built on a printed circuit board that plugs into an empty expansion slot on the motherboard.
AGRAS—An antiglare, antireflection, antistatic screen treatment that reduces glare and reflections from ambient and overhead lighting.
Alpha—A processor from DEC with clock speeds up to 275 MHz.
ANSI—American National Standards Institute. A committee that has developed standards in many fields, including ASCII, terminal emulation, and SQL format.
ARAG—An antireflection, antiglare screen treatment that reduces glare and reflections from ambient and overhead lighting.
ARAS—An antireflection, antistatic screen treatment that reduces glare and reflections from ambient and overhead lighting.
ASCII—American Standard Code for Information Interchange. The interna-

Operating systems

It's been said that hardware is the computer's brain, while the operating system is the mind—that is, this complex program gives a computer its basic capacity to accept commands and to "learn." (See Table 2.)

The basic operating system of PCs is MS-DOS: a 16-bit operating system developed by Bill Gates, founder of Microsoft, under contract to IBM. To make the computer do what you want under DOS, you have to type in arcane commands in a precise format (neatness counts!). Mistype one character in a long command line, and at best you'll have to retype the whole command—assuming that your DOS typo hasn't flung you somewhere you don't want to be.

Many users struggling with DOS have wondered whether Bill Gates deliberately created such an "unfriendly" system so that he could turn around and sell the world his more friendly overlay, Microsoft Windows. Requiring mouse clicks on graphic icons or word-fields instead of immaculate magic incantations, its operations resemble those of the Macintosh. Windows also gives PCs the capacity to run several applications or work on several files simultaneously (multitasking) by segmenting the screen area. Windows also includes numerous utilities and even some full applications. However, Windows requires a fast processor and considerable RAM (preferably a 486 on up, with at least 8 megabytes of RAM) to juggle these bells and whistles. Nonetheless, Windows has more new and updated applications written for it than any other operating system, making it the vehicle of choice.

About two years ago, Microsoft released Windows NT, a 32-bit stand-alone operating system that dispenses with DOS but in most other respects looks and behaves like regular Windows. The long-delayed Windows 95, released in August, is a full-bore, 32-bit DOS-free operating system that is replacing Windows in many new off-the-shelf computers. It includes a redesign of Windows' graphics, and has a host of built-in major applications and utilities (see Fig. 1). Applications written specifically for the 32-bit Windows NT and Windows 95 operating systems are plentiful, unlike the long-awaited applications promised for OS/2 WARP.

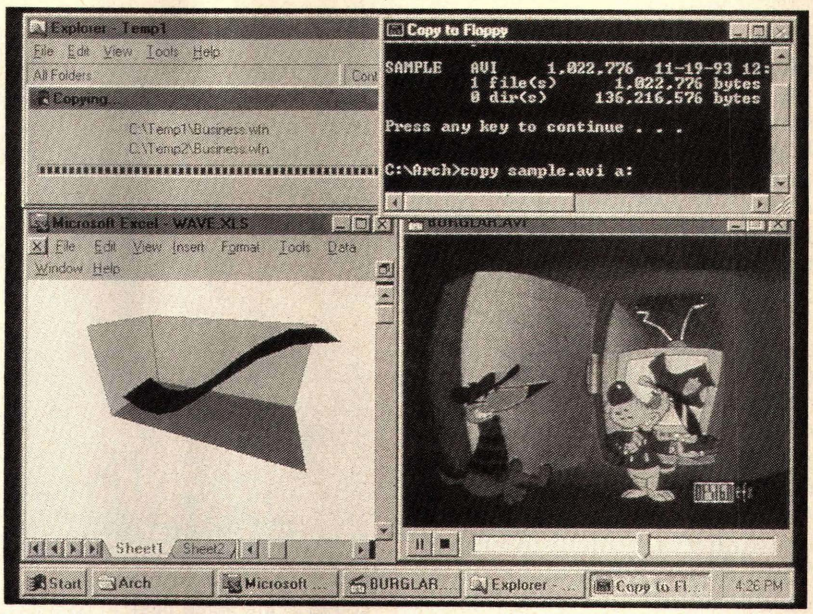

FIG 1— Microsoft's long-awaited Windows 95 was released in late 1995. It includes a redesign of Windows' graphics, and has true "Plug and Play" (called PnP) capabilities.

OS/2 WARP (or simply Warp), much advertised of late, isn't an interstellar drive, but merely IBM's latest foray into the 32-bit operating systems race. It's an update of OS/2, IBM's previous Windows' rival. Whatever its name, it's an umbrella package that subsumes three operating systems (DOS, Windows and OS/2), but in looks and functioning resembles both Windows and Windows 95. Unfortunately, it only operates at "warp speed" with programs designed specifically for it, which remain few and far between. However, it's expected that Apple may finally waft into Warp, facilitating software sharing between Macs and "warped" PCs.

Parallel processing

Making their desktop PC debut, after serving for many years in the mainframe world, are symmetrical multiprocessor (SMP) systems, which sport dual processors—two CPUs in parallel. In an SMP system run-

tional standard for turning alphanumeric characters and symbols into binary code.

ASP—Advanced Sound Processor. A sound technology introduced by Creative Labs (makers of Sound Blaster) which produces audio quality between that of synthesized voices and wavetables.

ASPI—Advanced SCSI Programming Interface. Developed by Adaptec to improve compatibility among SCSI devices.

associative cache— A cache scheme that saves data to relative memory addresses, as opposed to absolute addressing. Generally faster than direct-mapped cache.

AUI—Ethernet local area network using 15-pin D-shell connectors. Also called Thick Ethernet.

AVI—Audio video interleaved. Microsoft's standard file format for mixed digital video and audio.

BIOS—Basic input/output system. A small quantity of code used for controlling fundamental computer operations.

bps—Bits per second.

bus—A collection of multiple conductors that act as data paths in a computer along which information is transferred.

bus mastering—A method by which an expansion card transfers data to another expansion card or other peripheral via the expansion bus without involving the CPU.

cache—Any device, usually RAM, used to temporarily store data for immediate use, to provide faster access.

CAD—Computer-aided design.

CD-ROM—Compact disc, read-only memory. An optical disc that can store up to 680MB of data.

CD-Writer—A drive that lets you create your own CD-ROM discs.

Cheapernet—Ethernet local area network using coax cable wiring. Also called 10Base2 and thinnet.

ning a 32-bit operating system like Windows NT or OS/2, multiple operations can run virtually simultaneously—like the big boys, such as Cray supercomputers. Basically, the two processors divide the work load between them and actually process different parts of the code simultaneously.

Like all faster-than-light setups, it takes special SMP software that knows exactly when and where to split the instructions. In other words, don't expect Excel to run any faster with two CPUs than it does on one. And while most of the ads are for dual Pentium processors, SMP isn't limited to Pentium combinations. (See Fig 2.) For example, a Pentium can be paired with a 486 processor, given the right software.

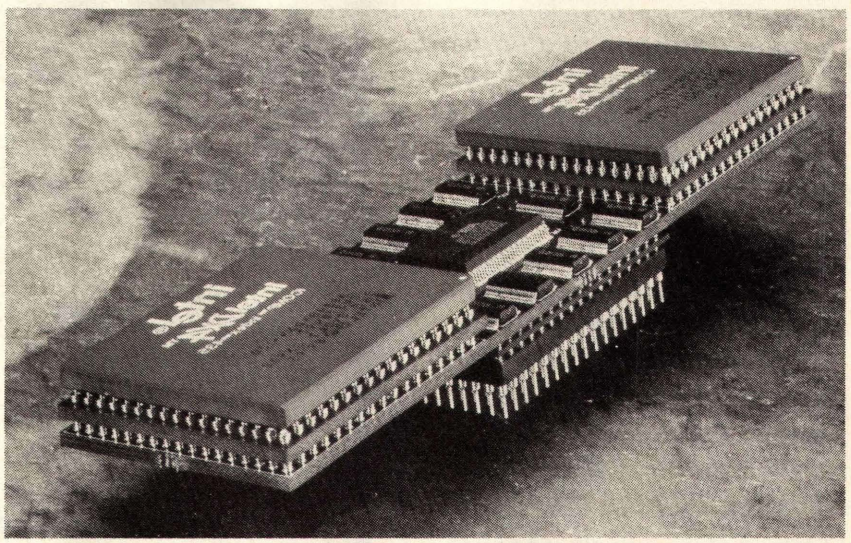

FIG. 2—Symmetric MicroProcessors (SMP) allows two processors to run separate codes at the same time, in parallel. Parallel processing is available as an option in select 486 and Pentium systems. If you wish to upgrade your present 486 system to SMP, Evergreen offers an eloquent solution called the Rev To SMP. It lets you mix and match any combination of 486 processors and/or Pentiums, and has provisions for 256K of secondary cache.

Memory and performance

While the CPU's speed and type generally establishes the PC's power, other factors such as memory type and size influence how effectively that power is used. There are two kinds of memory: cache memory and main memory.

Cache memory. Cache memory is a small, speedy chunk of RAM that holds the latest data the CPU has used (e.g., the work you're currently doing with an application), allowing immediate access to the data. Without cache, your system would have to consult the slowpoke disk drive constantly. There are two types of cache memory: primary cache and secondary cache. The primary cache is located inside the CPU itself. As pointed out earlier (see Table 1), all CPUs of 486 power and better have a built-in cache of 8K to 32K, depending on the processor. Still, this isn't enough cache for some large applications, so the processors have provisions for what's called secondary cache. The secondary cache is located on the motherboard, and ranges in size from 64K to 1 megabyte. As a rule, the larger the secondary cache, the faster the PC—but not always. It depends on the applications that it is running, so cache size *per se* isn't a good yardstick. Some secondary caches can be expanded, some can't. It's wise to ask about cache upgradability before you buy in case, next year, you discover that expanding your 128K secondary cache to 512K would greatly improve the performance of your spiffy new CAD program.

You might see an advertisement that says the secondary cache is write-back or associative. Write-back cache holds off writing to the hard disk until there's a lull in CPU activity. Write-through cache, on the other hand, interrupts the CPU to update the hard disk. While write-back is faster than write-through, it's not as safe—data can disappear if the power fails or your romping Rottweiler knocks the power cord out of the wall. Associative cache de-

chip doubler—Any of the 486DX2 or P24 OverDrive family of processors.
CISC—Complex instruction-set computing. CISC processors (typically Intel's i486) use longer instructions than RISC processors. While slower than a RISC CPU, virtually all applications are DOS and Windows CISC based.
CRT—Cathode-ray tube. The picture tube in your monitor or home TV set.
DAT—Digital audio tape. A tape cassette originally developed for consumer audio electronics that's finding widespread acceptance as mass storage backup. Each cassette holds about 1.2GB of uncompressed data.
direct-mapped cache—A cache scheme that saves data to absolute memory addresses for later use.
DMA—Direct memory access. A method where a peripheral or other devices access system memory directly without involving the CPU.
docking station—A desktop platform which has connectors and a power supply for a portable computer so that the portable can connect with a CRT monitor, printer, and other peripherals. Essentially, it turns a portable computer into a desktop computer.
double speed—Denotes a CD-ROM drive that has a data transfer speed of about 300 kilobytes per second. Triple-speed CD-ROMs run at 450 kilobytes per second, and quad-speed drives run at 600 kilobytes per second.
DTR—Data-transfer rate. A measurement of data throughput. Can be measured in MHz or bits per second (bps).
DTV—Desktop video. Any form of multimedia video that runs on a desktop computer.
DVI—Digital Video Interactive. Intel's standard file format for digital video; requires special hardware.
DX2—Any Intel CPU that runs internally at twice the speed of the motherboard and local bus slot.

scribes an alternative architecture to direct-mapped memory, and is generally faster than direct-mapped cache.

Just when you thought you knew all about cache memory, up comes Intel with its new Pentium OverDrive chip. This new P6 Pentium processor has 256K of secondary cache built right onto the chip, which all but eliminates the need for a motherboard cache. Yes, it's a lot faster than motherboard cache memory, but fixed in size. Bottom line: Before you buy, find out what the cache type is and where it's located.

Main memory. Main memory is usually composed of single inline memory modules or SIMMs plugged into the motherboard. As time passes, and new applications or multimedia packages demand more and more RAM, you'll probably want to expand the size of your main memory. Fortunately, except for the price, that's no big deal—most systems have plenty of room for more SIMMs.

The upgrade price varies. SIMMs come in two versions: 30-pin and 72-pin. The 72-pin variety is more expensive, but is often easier on the wallet because most motherboards that use them allow you to keep using your old SIMMs alongside the new ones, instead of having to replace them all as you generally have to do with the 30-pin variety.

The 72-pin SIMMs are available in two flavors: parity and non-parity. Although parity SIMMs are slightly more expensive, they are recommended because they provide some assurance on the integrity of your data. It is also important to remember that not all motherboards can support the use of non-parity SIMMs.

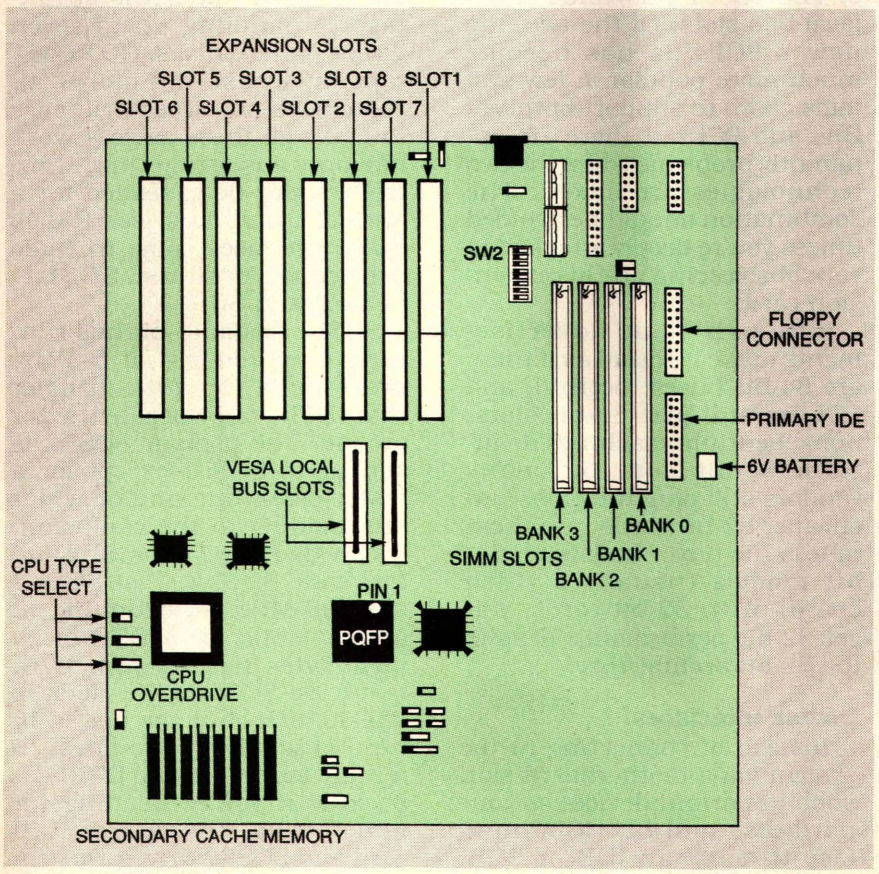

FIG. 3—The typical motherboard has many slots and sockets, starting with ISA/EISA and local bus expansion slots. The slots to the right are for SIMMs RAM, and there are sockets (lower left) for optional secondary cache memory. Many motherboards have a CPU OverDrive socket for upgrading the system.

Expansion slots

Expansion slots are used to plug peripherals into the motherboard (see Fig. 3). Confusion can begin with the phrase *local bus*. In fact, local bus is a bit of a misnomer: local buses are more like expresses, because they run at the same speed as the motherboard when they move data between the CPU and a peripheral (e.g., a video controller). For example, the local bus of a 486SX-25 runs at 25 MHz

DX4—Any Intel CPU that runs internally at three times the speed of the motherboard and local bus slot.
EISA—Extended industry-standard architecture. An aging 32-bit motherboard slot that's backward compatible with ISA (see ISA).
emulation mode—A software interface used by Alpha and other CPUs that interprets Windows and DOS instructions and converts them into the processor's native language.
Energy Star—A set of guidelines developed by the Environmental Protection Agency (EPA) to reduce power consumption in computer devices.
enhanced IDE—A recent upgrade of the popular IDE standard that runs at 16.7 MB per second and supports drives as large as 8.2GB.
enhanced parallel port—A parallel port capable of sending and receiving data at speeds approaching 1MB per second (compared to 80KB per second for a standard parallel port).
Ethernet—The most popular local area network (LAN) data transfer protocol. The most common versions are thinnet (10Base2), which uses coaxial cable, and 10BaseT, which uses twisted-pair telephone wire.
expansion slot—Any slot on the motherboard that accepts adapter cards.
flash BIOS—A reprogrammable memory chip (typically an EEPROM) used to store the computer's basic input/output instructions. Flash BIOS can be upgraded via software.
flat square—A nearly flat CRT display that has greater viewing area and less distortion than a spherical screen. Typically found in 15-inch and larger monitors.
fps—Frames per second. Refers to the speed at which full-motion video frames are displayed.
FPU—Floating-point unit. A math coprocessor that's specifically designed

and the local bus of a 486DX2-66 runs at 33 MHz. In contrast, most standard buses (ISA or EISA) run at a leisurely 8 MHz (see Table 3). Obviously, faster is better—but only if you really need the speed. For example, you gain nothing by plugging a 9600-bps modem card into a local bus slot, but if you plug a Windows accelerator video card into the same slot your graphics will gallop.

EISA/ISA. The original PC slot was an 8-bit ISA connector designed for the 8088-based IBM PC. In 1984, the ISA slot was upgraded to 16 bits for use in the IBM PC AT. Today's ISA slot is both 8- and 16-bit compatible, and is supported by the majority of board peripherals on the market.

The higher-priced EISA slot is an enhanced version of ISA that's mainly used in network servers. The best version has a 32-bit interface, and does *bus mastering* (a technique that lets two peripherals talk to each other without involving the CPU). Unfortunately, EISA has never received much support. Although ISA cards will run in EISA slots, they don't get any faster—so to increase your speed, you have to spend the cash to replace your current ISA peripherals with EISA equivalents. This isn't smart even if you can afford it: Even when you use EISA peripherals, the speed increase is noticeable only with a system that does a lot of I/O (input/output), such as a network file server.

VL-Bus and PCI. Both the VL-Bus (sometimes called VLB or VESA Local Bus) and PCI are local bus slots. Of the two, the newer PCI bus has become much more popular. A few systems claim to support both VL-Bus and PCI but there are apparently problems when the two technologies are mixed. The combination should be avoided unless you're deeply attached to your obsolescing VL-Bus expansion cards.

Although some advertisements make it sound as if these are 64-bit buses, both VL and PCI are still just 32-bit slots. Some Pentium machines do include 64-bit slots, but many vendors still plug the older and cheaper 32-bit cards into them unless the buyer insists on 64-bit models (usually a video board). With 32-bit cards, you get 32-bit performance despite the 64-bit architecture.

TABLE 3—BUS COMPARISONS

Expansion Slot	Data Bits	Typical Bus Speed	Data Transfer Rate
ISA	8/16	8 MHz	20 Mbytes/s
EISA	32	8 MHz	33 Mbytes/s
VL-Bus	32	33 MHz	120 Mbytes/s
PCI Local Bus	32/64	66 MHz	150 Mbytes/s

Device interfaces

Instead of connecting to the system via a motherboard slot, such important devices as your hard disk and CD-ROM interface through an IDE or SCSI bus.

SCSI. Installing a SCSI interface is no treat, but the end result (when you finally get it working) can be worth the torment. SCSI offers the advantage of handling up to seven devices—hard disks, CD ROMs, tape backups, and more—although it's not necessarily easy to make all these devices work harmoniously together. Controllers can be cascaded for a total of 28 devices (see RAID). SCSI interfaces come in three different versions, SCSI-1, SCSI-2, and SCSI-3.

SCSI-1 has an 8-bit bus running none-too-fast at 5 MHz, providing a top *data transfer rate* (DTR) of 5 megabytes per second. The popular SCSI-2 is similar to SCSI-1 except for a faster clock rate and/or wider bus. Adding to the confusion, it's divided into fast SCSI-2 and fast/wide SCSI-2. Fast SCSI-2 has a 10-MHz clock running on an 8-bit bus for a DTR of 10 megabytes per second. With fast/wide SCSI-2, the clock is still 10 MHz, but the bus is 16 bits wide which provides 20 megabytes per second DTR. Especially if you're heading for multimedia, the 16-bit SCSI card and SCSI-2 drives are generally considered to be worth the extra cost and hassle because they give faster performance and better compatibility.

to accelerate certain mathematical operations—generally those associated with spreadsheet and CAD applications.
IDE—Integrated drive electronics. The most popular type of hard-disk drive (see text for enhanced IDE).
Internet—A worldwide network of computer networks.
ISA—Industry-standard architecture. The most popular motherboard expansion slot. It typically runs at 8 MHz, which is a lot slower than a local bus slot.
kB/s—Kilobytes per second.
LAN—Local area network. Any interoffice, computer-to-computer connection that lets users share files and data.
LCD—Liquid-crystal display. The display media used for portable computers. It comes in three versions: passive, active, and dual-scan. (See text for details.)
LIS—Lithium-ion storage. The newest technology of batteries used in portable computers. Has a longer life and higher power-to-weight ratio than Ni-Cd or NiMH batteries.
local bus—Any motherboard slot that runs at the interface speed of the CPU. For a 486DX2-66 system, the local bus speed is 33 MHz.
memory cache—Fast RAM used to store frequently-used instructions or data. There are two types: primary cache, which is built into the CPU, and secondary cache installed on the motherboard.
MIDI—musical-instrument digital interface. A standard created by musical instrument manufacturers for the digitizing of music.
MO—magneto-optical. Any disk drive, including floptical, that uses a laser to write and to read a magnetic disk. Popular sizes are 3½ and 5¼ inches.
MPC—Multimedia PC. A specification that suggests the minimum hardware requirements for multimedia. (See Table 6.)

However, a special 68-pin cable is required for fast/wide. And while SCSI-2 is backward compatible with SCSI-1, you must have a fast/wide hard disk to run at top speed. A third version of SCSI is SCSI-3, which is not the same as fast/wide SCSI-2, and not popularly supported. The confusion here is that Quantum makes a SCSI-3 hard disk that some salespersons assume is SCSI-2 compatible—but it isn't.

IDE. Most new PCs come with an IDE interface built right into the motherboard. IDE devices remain more popular than SCSI devices because they're cheaper and easier to install.

Alas, IDE is a lackluster performer: It's basically meant to drive just a hard disk (not such additional peripherals as CD-ROM) and can only handle drives up to 528MB. Many PC users prefer the more expensive SCSI interface because of the latter's higher throughput, higher drive capacity, and the ability to daisy chain peripherals—not to mention its capacity to run multimedia applications at bearable speed.

However, the newly-developed *enhanced IDE* is poised to give SCSI a good run for its money, with its easy, affordable "plug and play" operation (see Table 4). This interface goes by several names: it's also called Fast ATA and High Performance ATA (depending on the manufacturer), but its most common name is EIDE. It has a data throughput of 16.7 megabytes per second, nearly that of fast/wide SCSI-2, it can support hard disks as big as 8.2 gigabytes, and one controller can handle four devices (instead of just two). For optimal performance, EIDE must be built into both the system and the drive, so keep this in mind when buying a system. You can't mix EIDE with IDE without losing your performance advantage: Plug a standard IDE hard disk into an enhanced system and it'll slow down the system to its own sluggish pace.

Monitors

The display (monitor) is your window on your PC's activities. You can use an old 14-inch VGA screen, but a superVGA color monitor is what it takes to enjoy a high-powered new computer—especially if you're buying into multimedia. Display terminology is especially bewildering; the most common terms you'll encounter follow. (Those not discussed can be found in the glossary).

The most popular term is "flat square," which describes the shape of the screen—although not very accurately. Generally found in monitors of 15 inches and larger, a flat-square CRT is neither flat nor square, but it's flatter and squarer than the spherical screen of a typical 14-inch monitor.

Most monitors have some kind of antireflective screen treatment to increase clarity by reducing glare and reflections from overhead lighting. The most common treatment is silica, followed by antireflection, antiglare (ARAG); antireflection, antistatic (ARAS); and antiglare, antireflective, antistatic (AGRAS). While it hasn't been proven that monitor emissions constitute a health risk, most new monitors comply with the Swedish Government's Department of Labor (SWEDAC) MPR II safety specifications for emissions.

Some monitors offer interlaced video mode, which draws the even lines on the screen in one pass and the odd lines on the next. Others monitors are non-interlaced, which means that all the lines are drawn sequentially from top to bottom. The potential downside is a constant headache-making flicker that is created because the top of the picture starts to fade by the time the bottom of the picture is being drawn. Flicker in noninterlaced monitors can be reduced by increasing the refresh rate (see Table 5).

TABLE 4—DRIVE INTERFACE COMPARISON

	IDE	Enhanced IDE	SCSI-1	SCSI-2 Fast	SCSI-2 Fast/Wide
Bus Width	8/16 bits	16 bits	8 bits	8 bits	16 bits
Data Transfer Rate	8 MB/s	16.7 MB/s	5 MB/s	10 MB/s	20 MB/s
Largest Hard Disk	528MB	8.2GB	10GB	10GB	10GB
Number of Drives	2	4	7	7	7

MPEG—Moving Picture Experts Group. Video compression schemes (MPEG 1, MPEG 2) used to reduce the size of animated video files.
MPR II—A rating established by Swedish government (SWEDAC) that limits potentially harmful monitor emissions to a safe level.
multimedia—A term used to describe any application that involves CD-ROM, sound, or motion video.
NI—Noninterlace scanning. A video mode that draws images on the screen one line after the other, as opposed to interlaced, which draws the even lines in one pass and the odd lines on the next pass. Has less flicker than interlaced scanning.
NiMH—Nickel-metal-hydride. The most popular rechargeable battery used in portable computers. It has a longer life than a nickel-cadmium battery and a faster recharge time (about 1 hour compared to 3 hours and more).
Nx586—A low-cost Pentium alternative from NexGen.
OverDrive—Any CPU upgrade chip that boosts the speed or power of 486, DX2, or Pentium system. While OverDrive is a trademark of Intel, other vendors make comparable upgrades that salespersons often mistakenly call OverDrives.
PCI—The most popular local bus standard.
PCMCIA—Personal Computer Memory Card International Association. The portable computer's equivalent of an expansion slot; uses peripherals the size of a credit card.
Pentium—Intel's high-speed successor to the i486.
Photo CD—A technique developed by Kodak that digitizes photographs and stores the files on a CD.
PowerPC—A processor developed by the collective minds of Apple, IBM, and Motorola that is compatible with both PC

The video display adapter is essentially an adapter card that plugs into a motherboard expansion slot. Most video cards sold today contain a Windows accelerator—a video controller chip that speeds up Windows-based applications. Some of these cards use VRAM for even faster response time, and all use a RAMDAC (sometimes called video DAC) to convert the digital signals into screen colors. The number of bits supported by the RAMDAC determines the number of screen colors. An 8-bit RAMDAC can do 256 simultaneous colors, while a 24-bit RAMDAC does 16.7 million colors. Many highly-pictorial CD-ROM programs recommend using the higher RAMDAC; in addition, this option allows users to decorate their on-screen "desktops" in subtle customized colors.

Upgrading

Many systems are advertised as upgradable—which is mainly true. Virtually all 486SX systems can be upgraded to 486DX2 status, and many 486DX2 systems can be converted into low-end Pentium compatibles.

CPU Upgrades. Virtually any 486-based PC can be upgraded from a lower to a higher CPU using an OverDrive chip. For example, it's easy enough to turn a 486SX-25 into a 486DX2-50 speedster or a 466DX2 into a 486DX4 with a simple brain (CPU) transplant. New on the scene are Pentium OverDrive chips that claim to turn 486DX2 systems into Pentium-compatibles. Does this mean that one day you could pop a new Pentium chip into your old 486 and give it a new lease on life? Well, not exactly. A 486 motherboard is just a 32-bit springboard, and the Pentium is a 64-bit processor. According to benchmark tests, Intel's Pentium OverDrive upgrade rarely delivers Pentium performance. Instead, you're far more likely to experience 486DX4-75 performance.

In some systems, you have to remove the old CPU from the motherboard to replace it with a faster one. Other machines include an empty socket just waiting for a new CPU. Removing a CPU from a standard socket on the motherboard requires a special tool that looks and works a lot like a small pry bar—and the process also requires great care to avoid damaging the motherboard. Be prepared to set some jumpers, too. Even when there's an empty motherboard socket for the new CPU, substantial force may be needed to insert the new chip, but if you apply too much pressure you can damage the motherboard or the OverDrive's pins.

ZIF Socket. A better solution is the ZIF or zero-insertion-force socket. (See Fig. 5.) ZIFs are two-layer sockets that start with a row of loose-fitting metal connectors mounted in a base plate. Just below the socket's base plate, surrounding these connectors, is a sliding plate drilled with holes that match

TABLE 5—VIDEO CONSIDERATIONS

Monitor Requirements			Video RAM Size vs. Screen Colors			
Resolution	Refresh Rate	Horizontal Scan Frequency	512 K	1 MB	2 MB	4 MB
640 by 480	60 Hz	31.5 kHz	65,536	16.8 million	16.8 million	16.8 million
	72 Hz	39.4 kHz	65,536	16.8 million	16.8 million	16.8 million
800 by 600	60 Hz	38 kHz	256	65,536	16.8 million	16.8 million
	72 Hz	48 kHz	256	65,536	16.8 million	16.8 million
1024 by 768	60 Hz	48 kHz	16	256	65,536	16.8 million
	72 Hz	60 kHz	16	256	65,536	16.8 million
1280 by 1024	60 Hz	64 kHz	4	16	256	65,536
	72 Hz	76 kHz	4	16	256	65,536

and Mac software.

R4000/R4400—Two different processors, the R4000 and R4400, from MIPS that run at speeds up to 150 MHz.

RAID—Redundant array of inexpensive drives. RAID refers to any of several methods where two or more disk drives are used to improve speed and/or reliability of a system. Generally used for networks.

RAMDAC—Random access memory, digital-to-analog converter. The chip that converts digital signals into screen colors. An 8-bit RAMDAC generates 256 simultaneous screen colors, and a 24-bit RAMDAC can do 16.8 million colors.

RISC—Reduced instruction set computing. RISC instructions are very simple and short, which allows the processor to run faster than CISC processors (see CISC).

SB compatible—Sound Blaster compatible. A de facto standard for interfacing the sound card with a CD-ROM drive.

SCSI—Small computer systems interface. Pronounced "scuzzy," SCSI is the fastest interface for hard disks. It's also the most expensive.

SIMM—Single in-line memory module. The staple of main memory, the SIMM comes in two versions, 30 pin and 72 pin.

SMP—Symmetrical multiprocessor. A technology that uses more than one processor in a single system.

superscalar—An architecture that lets the CPU execute two or more instructions per cycle as opposed to one instruction per cycle.

SX, SX2—An Intel CPU that's identical in every way to its DX and DX2 counterpart, except that it doesn't have a built-in math coprocessor.

TFT—Thin-film transistor. An active semiconductor device built into the screen of an LCD panel to improve

FIG. 4—Enhanced IDE can be added to existing systems by plugging in an EIDE controller card, like the Future Domain card above. These controllers support 16-bit multimedia devices, like IDE CD-ROM drives and IDE tape drives.

those of the socket. When the bottom plate is moved sideways using a lever, the connector holes reduce in size and clamp around the chips pins, making electrical contact and firmly holding the chip in place. Throwing the lever in the opposite direction releases the pressure for effortless chip removal.

Flash BIOS. An annoying thing about buying a state-of-the-art PC is that today's hot product is next month's (or even next week's) antique. The computer you bought at retail two days ago could actually be two versions behind what the company is shipping to vendors today.

To alleviate the problem, several vendors are equipping their systems with flash BIOS. In a nutshell, flash BIOS is a reprogrammable EEPROM device that lets you load the latest BIOS instructions into your PC via a simple program. These programs can be obtained directly from the vendor, or are oftentimes found on popular online services such as CompuServe and America Online.

Multimedia

The fastest growing sector of the PC market is multimedia—a term that generally refers to applications that make special use of audio and video. Popular multimedia applications include games, computer music, animation video, and reference and educational materials. The latter applications make optimal use of the "laser technology" information storage mentioned in IBM's ad: Instead of cluttering your house with multi-volume, weighty reference tomes, you get a 10-volume reference set stored on one or two tiny discs—with full-color, animated illustrations and sound effects, too.

At the heart of any good multimedia system is a CD-ROM. However, CD-ROM drives vary considerably in performance. For one thing, they come in different speeds. Single-speed CD-ROMs are so slow that their cost savings aren't worth the perpetual aggravation. Double-speed drives, which have a data-transfer rate of 300 kilobytes per second (kB/s). The more expensive drives run at triple speed (450 kB/s) and quadruple speed (600 kB/s). Sextuple-

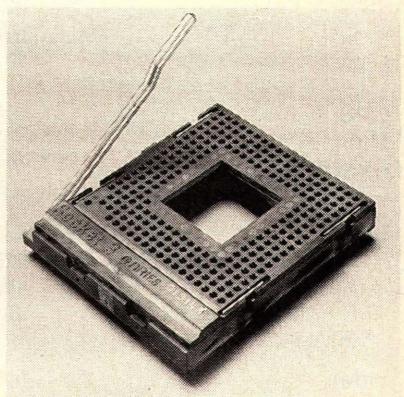

FIG. 5—ZIF sockets permit the easy insertion and removal of CPU chips, preventing damage to the chip and motherboard.

brightness and contrast.
V.32—The communications standard for 9600 bps modems.
V.32bis—The communications standard for 14.4 kbps modems.
V.34—The communications standard for 28.8 kbps modems.
VESA—Video Electronics Standards Association. A trade organization of graphics hardware manufacturers that develop guidelines for video products and expansion slots.
VL-Bus—The VESA local bus. An aging local bus that runs at speeds up to 66 MHz. Also advertised as VLB and VESA LB.
VRAM—Video random access memory. A dual-ported memory that speeds video displays, particularly Windows.
WAV—Microsoft's standard file format for audio sound.
wavetable—A method used by some sound boards to store the actual digital sounds of real instruments, resulting in more realistic sounds than those created by the synthesized voice method.
Windows accelerator—Any video board that uses a video chip with built-in instructions that increase the speed of Windows applications. Very few video boards sold today don't have a Windows accelerator.

speed drives might never see the light of day before new high-density CDs are introduced. Since CD-ROM technology is still fairly primitive, what you can expect from a double-speed installation is snail-speed navigation as you move through many CD-ROM applications (especially those making heavy use of video clips), herky-jerky video visuals, and ill-synchronized sound.

If you haven't bought a CD-ROM yet but you already own (or have your eye on) a bunch of multimedia software, you'll need to choose a system that supports the particular software you want to run. MPC and MPC2 define the minimum system requirements for CD-ROM multimedia applications (see Table 6). CD software packages usually tell you (right on their covers) which of these standards will be required for running the program. Virtually all new computers sold today exceed the MPC2 specifications.

While you can get sound from your PC's built-in speaker, you won't want to listen to it for long. A better bet would be to buy a sound board. Many sound boards claim to be compatible with the Sound Blaster, which is the *de facto* standard for interfacing the sound card with a CD-ROM. Sound cards commonly have a MIDI port for playing and composing music via an external keyboard or other MIDI device. The number of synthesized voices a sound board has, the better. The typical sound board has 20, more than enough for games, but not enough for serious MIDI work. Wavetables are actual digital recording samples of real instruments, and have a quality that synthesized voices can't match.

TABLE 6—MULTIMEDIA REQUIREMENTS

	MPC	MPC2
CPU	386 SX-20	486SX-25
Memory	2 MB	4MB
Hard Drive	30 MB	160 MB
CD-ROM Sustained DTR	150 kbps	300 kbps
Sound		
Sample Playback Rate	22 kHz, 8-bit	44 kHz, 16-bit
Sample Recording Rate	11 kHz, 8-bit	44 kHz, 16-bit
Synthesizer	8-voice, MIDI	8-voice, MIDI
MIDI in/out	Yes	Yes
Video		
Resolution and Colors	640 x 480, 256 colors	640 x 480, 65K colors
Kodak Multi-Session	No	Yes
Digital Video Playback	n/a	320 x 240, 15 fps

Portables

Since its introduction some ten years ago, the PC-compatible portable computer has undergone an incredible weight loss, from the 18-pound laptop luggage of 1986 down to today's six-pound notebooks and four-pound subnotebooks.

Unlike desktop computers, portables have an LCD screen instead of a CRT. Basically, there are three types of LCDs: passive, dual-scan, and active. Passive LCD displays are the dimmest. They consist of a liquid-crystal panel with a grid of wires on each side of the display forming a matrix. When voltage is applied to the matrix it polarizes the liquid crystal and lets light pass through. However, at VGA scanning rates, the voltage isn't applied long enough for the liquid crystal to completely untwist, which results in low contrast. Dual-scan LCDs improve the contrast by dividing the screen in half, and simultaneously scanning the top and bottom halves. Better yet are active-matrix screens with thin-film transistors (TFTs) on the inside surface that amplifies the current to make the liquid crystal open faster and more fully.

Most notebooks and subnotebooks come with at least one PCMCIA slot. This is the portable's equivalent of the desktop's ISA or local-bus slot: It's used for such plug-in devices as modems, network adapters, hard disks, and memory. PCMCIA cards come in three standard thicknesses (Types I, II, and III), and their slots can be stacked to allow a thicker Type II card to plug into two thinner Type I slots.

Because space inside the portable is so limited, such peripherals as large disk drives and CD-ROMs are often connected externally via the parallel port. A recent advance is the enhanced parallel port, which moves data to and from the computer and external peripherals at a much faster rate than a conventional parallel port. A docking station converts a laptop into a desktop by providing connections for a monitor along with multiple serial and parallel ports.

Until recently, portables were

powered by Nickel-Cadmium (Ni-Cd) batteries. Today most notebooks and subnotebooks are powered by Nickel Metal Hydride (NiMH) batteries, which are less toxic and store more energy in a smaller space. Lithium storage batteries (LIS), the most efficient and least toxic choice, are just coming into use: They last longer and store more energy per pound than either Ni-Cd or NiMH.

Communications

PC communications technology has advanced far beyond the lethargic modems of yesteryear. Modem speed is measured in bits per second (bps).

Today's lowest-end modems run at 2400 bps (twice as fast as the old 1200 bps models, but still far from rapid—avoid them if you can.) The better ones run at rates of 14.4 kilobits per second (kpbs), and many run at the new standard speed of 28.8 kbps. Modem speed adjusts downward automatically as needed: Two modems of widely different speed (say, 1200 and 14.4K) can still communicate—at the slower modem's rate.

Buying smart

No article about computers can hope to be comprehensive—especially with the speed that the computer industry changes and that computer technology advances. The first rule before you buy is to ask questions; if you don't know what something means, ask. If the vendor won't give you a clear answer, find another one who will. Ω

PARTY LINE

continued from page 129

agram of the circuit. It consists of five major sections: Input, step-up, microcontroller, DTMF decoder and call-progress generator, and power. Note in the figure that there are three separate grounds, one each for the analog circuitry, the digital circuitry, and the high-current devices. The three grounds unite at the power supply.

The input section consists of six identical phone-line interfaces. Each includes an LED status indicator, an opto-coupler that after buffering informs the MCU that a line has gone off-hook, and a DPDT relay that switches the tip and ring connections of a line between the talk and ring circuits.

The step-up circuit buffers the 20-Hz ring signal from the MCU and then uses a push-pull amplifier arrangement to drive a reverse-coupled transformer. The transformer steps the circuit-level ring-voltage up to about 90 volts.

The microcontroller section is the brains of the Party Line. The MCU uses task-based scheduling software to ensure that all activities are tended to in a timely fashion. The MCU reads configuration information, maintains the real-time clock, monitors and controls line status of all six stations, drives the status LED, generates the 20-Hz ring signal, generates the CID tones, and performs general housekeeping.

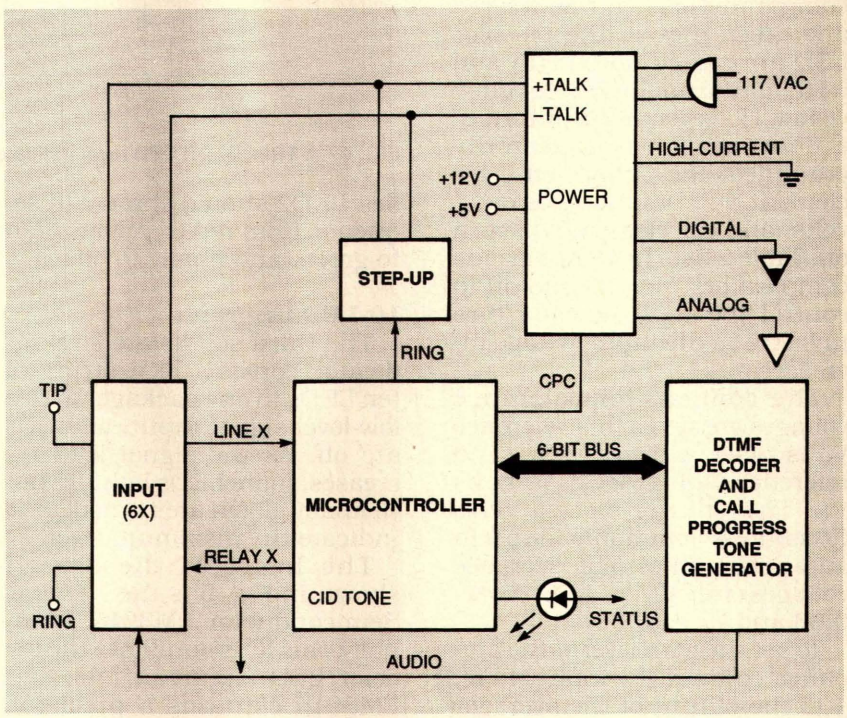

FIG. 2—PARTY LINE BLOCK DIAGRAM: There are separate ground lines for the analog circuitry, the digital circuitry, and the high-current devices.

The DTMF decoder and call-progress generator are built from a couple of special-purpose IC's. One performs DTMF tone decoding, transferring its information to the MCU via the attached bus. The other generates several call-progress tones depending on the binary codes at its inputs. The bus also delivers that binary code, as well as control signals for latching information out of the DTMF decoder and into the call-progress generator.

This section also contains a two-stage op-amp buffer for coupling the MCU-generated CID tones into the audio portion of the circuit.

Last, the power supply delivers regulated sources of +5-volts DC and +12-volts DC, as well as a regulated +28-volt talk voltage. The only unusual thing about the power supply is that the talk-voltage regulator can be disabled under software control. The purpose of that is to support a seldom-used telephone feature called Calling Party Control (CPC).

When we pick up next time, we'll provide a more detailed description of the circuit, including complete schematics. Then we'll discuss construction, configuration, and use. Ω

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colors. These reference voltages are fed to the three comparators along with the input signal. Notice that the input signal is connected to the inverting (-) input of one comparator (IC3-b) and to the noninverting (+) input of the other two comparators (IC3-c, IC3-d).

The output of these comparators is then connected to LED2. If the output of all of the comparators is floating, the red and green dies in the tri-color LED are biased on by R15 and R16, causing LED2 to glow yellow. However, if the output of a comparator is internally grounded, the connected color element will be pulled below 2 volts, and the element will turn off. Table 2 lists how the various comparators turn on and off to control the separate color dies in LED2 as the input voltage increases.

The comparator reference voltages are set so that reference V_Y is twice as large as V_G and reference V_R is twice as large as V_Y. This power-of-two relationship is commonly found in audio electronics. The reference voltages are: V_R = 1.26, V_Y = 0.63 and V_G = 0.32.

To set the gain level of the amplifier, connect the input of Fig. 4 to the output of the averager circuit in Fig. 2. As with the previous level indicator, apply a maximum-level signal to the input of the averager, and reduce the level to allow for headroom. Then, adjust R2 in Fig. 2 until LED2 just turns red. Now slowly reduce the audio input-signal level at the input to the amplifier. LED2 should change in sequence from red to yellow, then to green, and finally to off.

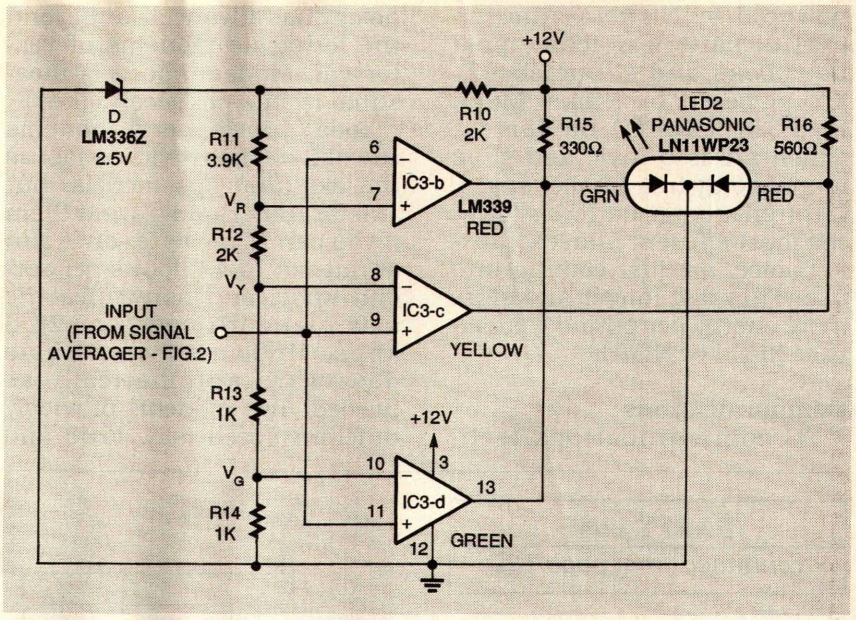

FIG. 4—A TRI-COLOR LED level indicator circuit.

10-LED bargraph

The third solid-state level indicator consists of a string of ten LEDs in one package. With a low-level signal input, all LEDs are off. As the signal level increases, more LEDs light up until finally all ten are turned on to indicate the maximum level.

The heart of the circuit shown in Fig. 5 is the National Semiconductor LM3915. Internally, this IC is similar to the tri-color LED circuit *in toto*. The LM3915 contains a precision voltage reference, resistor divider chain, and ten comparators to drive the LEDs. This IC also contains current-limiting circuitry that limits the brightness of the LEDs without the need for separate resistors, and logic to select either a bargraph or a moving-dot display. In Fig. 5, the bargraph display is selected because pin 9 of IC5 is tied to the same voltage point as pin 3 of IC5. If pin 9 is allowed to float,

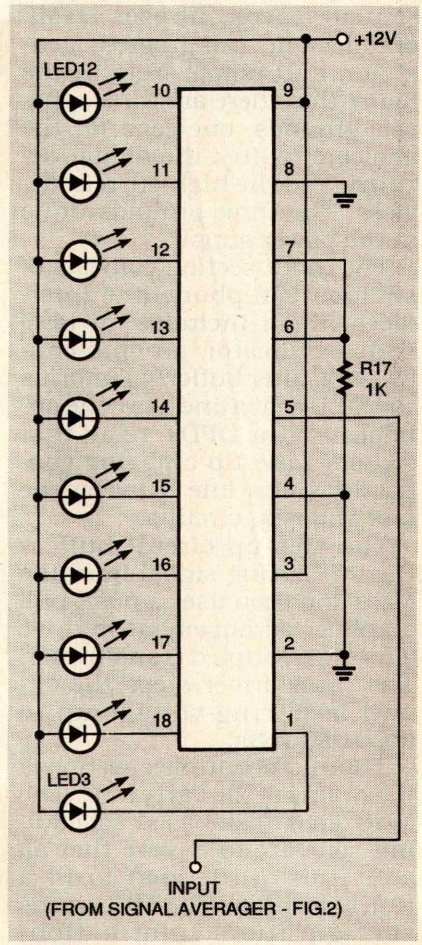

FIG. 5—A TEN-LED BARGRAPH level indicator.

TABLE 2—TRICOLOR LED COMPARATOR OUTPUT

Input Level	IC3-b Output	IC3-d Output	Green Element	IC3-c Output	Red Element	LED2 Color
Less Than V_C	Float	Ground	Off	Ground	Off	Off
V_G to V_R	Float	Float	On	Ground	Off	Green
V_Y to V_R	Float	Float	On	Float	On	Yellow
More Than V_R	Ground	Float	Off	Float	On	Red

the IC would program one LED to turn on at a time to provide a moving-dot display. The voltage references are set to the standard step increments used in audio electronics equipment to match the response to the volume heard by the human ear.

Set the illuminating response level of the bargraph LED indicator following the same procedure as previously described for the other LED circuits. Connect the output of Fig. 2 of the averager circuit to the input of the bargraph level indicator in Fig. 5. Apply a maximum level signal to the input shown in the averager circuit of Fig. 5, and reduce the input level to allow for headroom. Then adjust R2 in Fig. 2 until the most significant LED (LED12 in Fig. 5) just turns on.

Picking the LED level indicator

The selection of the most appropriate LED level indicator depends on the existing arrangement of controls. If the front panel is already cluttered with knobs and switches, there might only be room for a single LED. However, if the front panel has room to spare, a ten LED bargraph might fit on it. Its installation could give the audio equipment a professional appearance. (Remember, you need two bargraphs for a stereo system.) The LEDs that make up the bargraph can be positioned vertically, horizontally, or even in an arc to convey the impression of a moving needle of a meter. Also, the LEDs can have different colors. Use red for the high levels, green for the low, and yellow for those in-between.

If only one LED will fit on the crowded panel, chose between a single-color LED or a tri-color LED. The tri-color LED has more resolution because it has four color states. However, if all you need is an overload detector, the single-color LED is a better choice because it clearly conveys a message of *too high*.

Finally, keep in mind that the addition of a solid-state level indicator might excite audiophiles who will admire and want to try out your project. Ω

WAVEFORM GENERATORS

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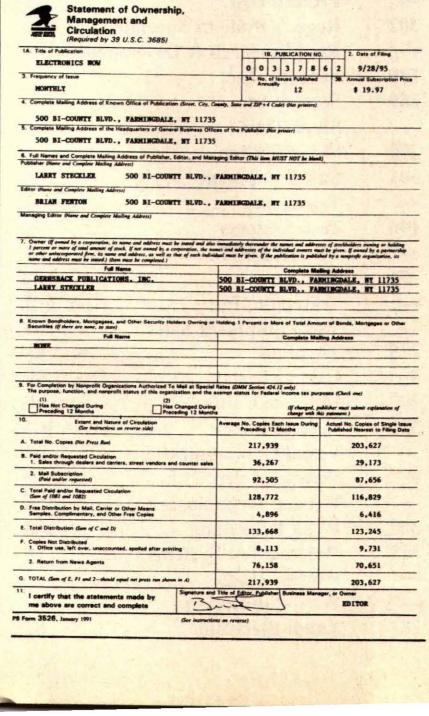
showing how the tuned-collector oscillator in Fig. 13 can be modified to act as a 455-kHz, beat-frequency oscillator (BFO). It is tuned by adjusting a voltage-variable capacitor with potentiometer R5. Transfomer T1 is a standard 455-kHz transformer for transistorized circuits, and silicon diode D1 functions as an inexpensive voltage-variable capacitor.

When a small-signal silicon diode is reverse biased, its effective capacitance varies with the applied voltage. Its capacitance value is inversely related to the applied voltage. Some silicon diodes are optimized to function as dedicated voltage-variable capacitors, but the industry standard 1N4001 diode will demonstrate this function satisfactorily for any experimental purposes.

In Fig. 18, capacitor C2 and the effective capacitance of D1 are in series, and the combination is connected across the tuned circuit of transformer T1. (Capacitor C2 blocks DC between transistor Q1 and diode D1.) This configuration permits the Reinartz oscillator's center frequency to be changed by altering the capacitance of D1 with potentiometer R5. Ω



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PS Form 3526, January 1991 (See instructions on reverse)

PC-BOARD DESIGN

continued from page 127

tion on the worksheet. As long as a device remains highlighted, it may be placed as many times as you wish. Components may be rotated in 90-degree increments or mirrored.

Pads and vias are shown as icons in a tool box just above the list, along with the tools needed for laying down tracks. The tool box contains a list of 20 common pad sizes and shapes, but you may add as many of your own design as you wish. Vias are placed automatically when you switch between the two layers while drawing a track. Unfortunately, like Easy-PC, the track is invisible during the drawing process, and becomes visible only when the two endpoints are defined, making it difficult to judge corners. Once a track is in place, there's a slick trick built into the editing program that lets you neck down segments of the track.

PCB II supports all the popular printers and plotters, and generates Gerber, N/C Drill, and PostScript files, as well as silk screen and solder masks. Included in the printer output options are a file redirect that lets you produce output files suitable for graphics import into many popular word processor and desktop publishing programs. Unique to PCB II is a Gerber file viewer that lets you see what your board will look like before you send the design off to a service house.

PCB II has a lot of nice features, including a large number of device outlines, an unlimited number of pad shapes and track widths, and support for boards up to 30 inches. The program is easy to use—once you've mastered it—and it abounds with advanced drawing and editing features that help speed up the layout process. Add Supersketch to that, and you've got a sound package for the active hobbyist.

Next month, we'll continue with a look at packages that combine PC-board layout with schematic-capture capability. Ω

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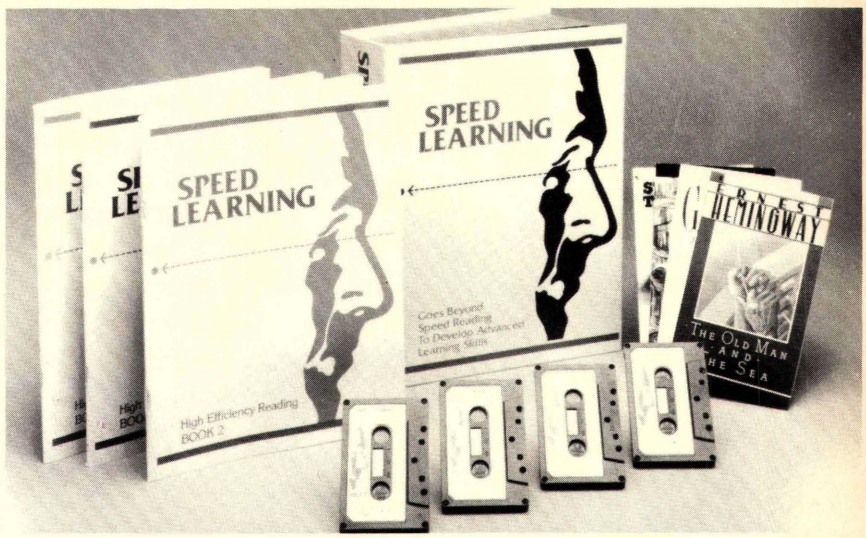

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